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APPENDIX B

MBTA CONSTRUCTION SPECIFICATIONS

FOR

RAILROAD GRADE CROSSING RECONSTRUCTION WORK

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

CONSTRUCTION SPECIFICATIONS

FOR RAILROAD GRADE CROSSING RECONSTRUCTION WORK

APPENDIX B

SUPPLEMENTING MASSDOT SPECIAL PROVISIONS
SILVER LINE GATEWAY
CHELSEA, MA

MASSDOT PROJECT FILE NO. 604428

FOREWORD

The MBTA's Standard Plans referred to herein is the book of plans entitled "MBTA Railroad Operations – Book of Standard Plans – Track and Roadway"; which is available for download on MBTA.com. Also, the MBTA's Standard Plan entitled "MBTA Railroad Operations – Commuter Rail Design Standards Manual" is available for download on MBTA.com Bidding documents are available for download from an MBTA FTP site, or on a CD via Fed Ex. Interested parties must complete the Project Plans Request Form on individual project pages at:
http://www.mbta.com/business_center/bidding_solicitations/current_solicitations/

Plans referenced in this book are referred to as STANDARD PLAN (Number).

SUMMARY OF THE WORK

PART 1 - GENERAL

1.1 GENERAL

A. The Work shall be performed in accordance with the following documents as issued by the Massachusetts Department of Transportation (MassDOT):

1. The Standard Specifications which includes the Instructions to Bidders, and General Conditions.

2. The Contract Special Provisions which includes the Notice to Bidders; Instructions to Bidders; Federal and State requirements.

3. The Supplemental MBTA Construction Specifications contained herein

4. The Contract Drawings

B. The Work shall be performed in accordance with the following documents as issued by the Massachusetts Bay Transportation Authority:

1. The Standard Specification which includes the General Conditions; and Divisions 1A through 16.

1.2 CONTRACT DESCRIPTION, COMMENCEMENT AND COMPLETION TIMES

A. Description

The Project consists of the construction of the Silver Line Gateway Project in Chelsea. Work under these supplemental MBTA Specifications consists of construction of the Railroad Grade Crossing Reconstruction, including but not limited to track construction, grade crossing rehabilitation, removal of automatic signal locations, track surfacing and alignment and the retirement or demolition of existing track and signal system elements.

1.3 CONSTRUCTION PHASING

A. Construction Phasing of the work shall be planned in such a manner that will maintain uninterrupted existing operations of the MBTA Commuter Rail Service, operated by Keolis Commuter Services, as well as freight operations.

B. Construction Phasing of the work shall also be planned in such a manner that will maintain uninterrupted operations of the existing Chelsea Commuter Rail Station, located between Arlington Street and Washington Avenue. The Contractor shall prepare a

detailed construction plan for submission to the MBTA on how commuter rail passenger services will be maintained at the station during construction. .

C. The Contractor shall coordinate all construction activities with the appropriate agencies of the City of Chelsea, and shall avoid construction related impacts on the adjacent and adjoining areas.

D. All necessary and required permits and approvals from the City of Chelsea, shall be obtained by Contractor. All other necessary and required approvals from the MBTA, MBCR, utility companies, abutters, etc. shall also be obtained by Contractor

1.4 LIMITS OF WORK AND ACCESS TO SITES OF WORK

A. The Contractor is to restrict work to MBTA, or State owned areas or areas within a public right-of-way. However, any additional areas which the Contractor might require, shall be secured by the Contractor at the sole expense and responsibility of the Contractor, but written evidence thereof shall be furnished to the MassDOT. Prior approval from the MassDOT and the owner will be required.

B. Prior to the commencement of construction, the Contractor shall present the Authority with a detailed plan of how he will perform the work on this project without impacting Commuter Rail Service and Railroad Operations. The plan should also identify how materials and equipment will be delivered to the construction site. This plan cannot be implemented until it is approved by the Authority.

C. Contractor will not be allowed to work within the “foul” area of the railroad (15 feet, or the potential to be within 15 feet, from centerline of track) without flagmen and/or track foremen present from the operating railroad.

D. Contractor shall be responsible for coordinating with the local utility companies for relocation of their facilities as required for the construction of all work.

1.05 EXISTING CONSTRUCTION AND CONDITIONS

A. The MassDOT believes that information on the drawings describing existing construction or conditions is correct insofar as it is shown; however, it does not guarantee or represent that existing construction, utilities or conditions conform to the drawings. The Contractor shall visit the site and satisfy himself as to the existing conditions. No claim for extra cost will be allowed because of the Contractor's unfamiliarity with observable site conditions.

B. In case of discrepancies being found in the Contract Documents, the Contractor shall immediately report them to the Engineer and shall commence no new work nor place orders concerned with the matter in doubt until resolution is made by the Engineer.

1.06 REPAIRING AND REPLACING EXISTING WORK

A. The Contractor shall work through the Engineer to obtain the necessary coordination with the Operation and Maintenance Departments of the Authority in order to permit construction progress with the most possible cooperation. MBTA commuter service shall be maintained uninterrupted. Furthermore, the Contractor shall coordinate his efforts with other Contractors working on separate contracts in the immediate vicinity of the construction sites.

1.07 WARRANTY OF WORK

A. Neither final acceptance, final payment nor any provision in the Contract Documents nor partial or entire use or occupancy of the premises by the Authority shall constitute an acceptance of work not done in accordance with the Contract Documents or relieve the Contractor of liability with respect to any express warranties or responsibility for faulty materials or workmanship.

PART 2 - PRODUCTS

PART 3 - EXECUTION

PART 4 - MEASUREMENT AND PAYMENT

Not Used.

END OF SECTION

SECTION 02221

DEMOLITION

PART 2 - GENERAL

2.1 DESCRIPTION OF WORK

A. Work Included: This Section specifies the following items:

1. Demolition, selective demolition and removal of site improvements.
2. Removing below-grade construction.
3. Disconnecting, capping or sealing and removing site utilities.
4. Removing of retired signal equipment and instrument houses
5. Salvaging items for reuse by the Authority.
6. Removal of track material and its disposition

B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 01571 Maintenance and Protection of Railroad Traffic
2. Section 02300 Earthwork.
3. Section 02852 Commuter Track Construction

2.2 DEFINITIONS

A. Demolish: Completely remove and legally dispose of off-site.

B. Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to Authority ready for reuse. Include fasteners or brackets needed for reattachment elsewhere.

C. Hazardous Material: include but is not limited to asbestos and materials regulated under TSCA, RCRA (310CMR 30.00) and the Massachusetts Contingency Plan (MCP) (310 CMR 40.00) and building construction material defined by OSHA. Where applicable, consideration should be given to MSDS in determining if a material could be potentially hazardous.

2.3 MATERIALS OWNERSHIP

A. Unless otherwise indicated, demolition waste becomes property of Contractor.

B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Authority that may be uncovered during demolition remain the property of Authority.

1. Carefully salvage in a manner to prevent damage and promptly return to Authority.

C. All turnouts, crossovers, rail and other track materials shall be designated as salvage material and delivered to the Authority

D. All timber ties and switch timber removed shall be removed from the Authority's property and disposed

2.4 SUBMITTALS

A. Proposed Protection Measures: Submit informational report in accordance with OSHA Part 1926 procedures, including drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and for noise control. Indicate proposed locations and construction of barriers.

1. Adjacent Buildings and Structures: Detail special measures proposed to protect adjacent buildings and structures to remain.

2. Adjacent trackwork and systems equipment: Detail special measures proposed to protect adjacent trackwork and systems equipment to remain.

B. Provide detailed sequence of demolition work, with starting and ending dates for each activity.

C. Provide schedule of temporary interruption of utility services.

D. Provide details for shutoff and capping or re-routing of utility services.

E. Inventory: Submit a list of items to be removed and salvaged and deliver to Authority prior to start of demolition.

F. Predemolition Photographs or Video: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by building demolition operations. Comply with Division 1. Submit before the Work begins.

G. Hazardous material remediation plan. Included in the plan are landfill records indicating receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.

H. Results of Professional Engineer's survey required by Article 3.1D.

I. All submittals shall be approved before work may proceed.

2.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

B. Standards: Comply with ANSI A10.6 and NFPA 241.

C. Prepare a hazardous material remediation plan and submit to Authority for approval.

D. Predemolition Conference: Conduct conference at Project site to review methods and procedures related to building demolition including, but not limited to, the following:

1. Review of hazardous material remediation plan.

2. Inspect and discuss condition of construction to be demolished.

3. Review structural load limitations of existing structures.

4. Review and finalize building demolition schedule and verify availability of demolition personnel, equipment, and facilities needed to make progress and avoid delays.

5. Review and finalize protection requirements.

6. Review procedures for noise control and dust control.

7. Review procedures for protection of adjacent buildings.

8. Review items to be salvaged and returned to Authority.

2.6 PROJECT CONDITIONS

A. Signal Instrument Houses and cases to be demolished will be vacated and their use discontinued before start of the Work.

B. Buildings immediately adjacent to demolition area may be occupied. Conduct building demolition so operations of occupied buildings will not be disrupted.

1. Provide not less than 72 hours notice of activities that will affect operations of adjacent occupied buildings.

2. Maintain access to existing walkways, exits, and other facilities used by occupants of adjacent buildings.

a. Do not close or obstruct walkways, exits, or other facilities used by occupants of adjacent buildings without written permission from authorities having jurisdiction.

C. The Authority assumes no responsibility for buildings and structures to be demolished.

1. Conditions existing at time of inspection for bidding purpose will be maintained by Authority as far as practical.

D. Hazardous Materials: Hazardous materials may be present in buildings and structures to be demolished. A report on the presence of hazardous materials is on file at the Authority for review and use. Examine report to become aware of locations where asbestos, lead paint or other hazardous materials are present. Do not disturb hazardous materials or items suspected of containing hazardous materials except under procedures specified or required by a licensed professional and/or agency having jurisdiction.

E. On-site storage or sale of removed items or materials is not permitted.

F. Construction Access and Staging

1. Special attention shall be given to sequence demolition staging work so the MBTA Commuter Rail operations are not affected with respect to safety, operation and schedule.

2. All materials removed as part of this demolition shall become the property of the Contractor and are to be disposed of properly according to applicable local, State and Federal regulations, unless otherwise specified by the Engineer.

2.7 COORDINATION

A. Arrange demolition schedule so as not to interfere with Authority's operations and operations of adjacent occupied buildings.

B. Demolition shall proceed in sections. The demolition work must be performed in conjunction with the approved sequence of construction plans.

C. A minimum of one track must be in operation at all times. This track will be active during all demolition activities. The contractor must take steps to ensure that his operations will not impact rail service.

PART 3 - PRODUCTS (Not Used)

PART 4 - EXECUTION

4.1 EXAMINATION

A. Verify that utilities have been disconnected and capped before starting demolition operations.

B. Review Project Record Documents of existing construction provided by Authority. Authority does not guarantee that existing conditions are same as those indicated in Project Record Documents.

C. Inventory and record the condition of items to be removed and salvaged. Provide photographs or video of conditions that might be misconstrued as damage caused by salvage operations.

D. Engage a professional engineer to perform an engineering survey of condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during building demolition operations.

E. Verify that hazardous materials have been remediated before proceeding with building demolition operations.

4.2 PREPARATION

A. Existing Utilities: Locate, identify, disconnect, and seal or cap off indicated utilities serving buildings and structures to be demolished.

1. Arrange to shut off indicated utilities with utility companies.

2. If removal, relocation, or abandonment of utility services will affect adjacent occupied buildings, then provide temporary utilities that bypass buildings and structures to be demolished and that maintain continuity of service to other buildings and structures.

3. Cut off pipe or conduit a minimum of 24 inches below grade. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing according to requirements of authorities having jurisdiction.

B. Existing Utilities: Refer to Contract Documents for shutting off, disconnecting, removing, and sealing or capping utilities. Do not start demolition work until utility disconnecting and sealing have been completed and verified in writing.

C. Temporary Shoring: Provide and maintain interior and exterior shoring, bracing, or structural support to preserve stability and prevent unexpected movement or collapse of construction being demolished.

1. Strengthen or add new supports when required during progress of demolition.

D. Salvaged Items: Comply with the following:

1. Clean salvaged items of dirt and demolition debris.

2. Pack or crate items after cleaning. Identify contents of containers.

3. Store items in a secure area until delivery to Authority.

4. Transport items to storage area designated by Authority.

5. Protect items from damage during transport and storage.

4.3 PROTECTION

A. Existing Facilities: Protect adjacent walkways, loading docks, building entries, and other building facilities during demolition operations. Maintain exits from existing buildings.

B. Existing Utilities: Maintain utility services to remain and protect from damage during demolition operations.

1. Do not interrupt existing utilities serving adjacent occupied or operating facilities unless authorized in writing by Authority and authorities having jurisdiction.

2. Provide temporary services during interruptions to existing utilities, as acceptable to Authority and authorities having jurisdiction.

a. Provide at least 72 hours notice to occupants of affected buildings if shutdown of service is required during changeover.

C. Temporary Protection: Erect temporary protection, such as walks, fences, railings, canopies, and covered passageways, where required by authorities having jurisdiction and as indicated. Comply with requirements in Division 1and 1A.

1. Protect adjacent buildings and facilities from damage due to demolition activities.

2. Protect existing site improvements, appurtenances, and landscaping to remain.

3. Erect a plainly visible fence around drip line of individual trees or around perimeter drip line of groups of trees to remain.

4. Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.

5. Provide protection to ensure safe passage of people around building demolition area and to and from occupied portions of adjacent buildings and structures.

6. Protect walls, windows, roofs, and other adjacent exterior construction that are to remain and that are exposed to building demolition operations.

7. Erect and maintain dustproof partitions and temporary enclosures to limit dust, noise, and dirt migration to occupied portions of adjacent buildings.

D. Remove temporary barriers and protections where hazards no longer exist. Where open excavations or other hazardous conditions remain, leave temporary barriers and protections in place.

4.4 DEMOLITION, GENERAL

A. General: Demolish indicated existing buildings and site improvements completely. Use methods required to complete the Work within limitations of governing regulations and as follows:

1. Do not use cutting torches until work area is cleared of flammable materials. Maintain portable fire-suppression devices during flame-cutting operations.

2. Maintain fire watch during and for at least four hours after flame cutting operations.

3. Maintain adequate ventilation when using cutting torches.

4. Locate building demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.

5. In general, demolish buildings top down.

B. Engineering Surveys: During demolition, perform surveys to detect hazards that may result from building demolition activities.

C. Site Access and Temporary Controls: Conduct building demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, walkways, or other adjacent occupied or used facilities without permission from Authority and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

2. Use water mist and other suitable methods to limit spread of dust and dirt. Comply with governing environmental-protection regulations. Do not use water when it may damage adjacent construction or create hazardous or objectionable conditions, such as ice, flooding, and pollution.

D. Explosives: Use of explosives is not permitted.

4.5 DEMOLITION BY MECHANICAL MEANS

A. Remove debris from elevated portions of the work by chute, hoist, or other device that will convey debris to grade level in a controlled descent.

1. Remove structural framing members and lower to ground by method suitable to minimize ground impact and dust generation.

B. Salvage: Items to be salvaged are indicated on Drawings.

C. Below-Grade Construction: Demolish foundation walls and other below-grade construction that are within footprint of new construction and extending 5 feet outside footprint indicated for new construction. Abandon below-grade construction outside this area.

1. Remove below-grade construction, including basements, foundation walls, and footings, to at least depths indicated.

D. Existing Utilities: Abandon existing utilities and below-grade utility structures. Cut utilities flush with grade unless indicated otherwise.

4.6 REMOVAL

A. Remove entirely existing miscellaneous structures and site improvements that interfere with construction within the limits described or as designated by the Engineer. Remove walls and masonry construction to a minimum depth of two feet below existing ground level in areas where such items do not interfere with construction.

B. Remove all material generated by removal operations and other related operations off the site and dispose of in compliance with all applicable laws and regulations.

C. All removal and disposal must be done in accordance with applicable state and federal laws.

D. Any element to be removed that performs a safety function – such as fencing and signage – shall not be removed until its safety function is no longer necessary or has been replaced.

4.7 SALVAGE

A. Salvage indicated material or material determined by the Engineer to be suitable for reuse, including: grates, frames, other metal castings and miscellaneous parts of inlets and manholes; hydrants, fire alarm posts and boxes; metal light poles; sound pipe and valves; metal fencing; guard rail; highway and street signs and posts shall be delivered to the MBTA.

B. Protect metallic coatings on salvaged items. Remove adhering concrete from salvaged items where required for disposal or directed by the Engineer.

C. Repair, or replace with new material, salvaged material damaged or destroyed due to the Contractor's negligence.

D. All items designated as "remove" and not relocated as part of this project, and determined to be in salvageable condition by the engineer, shall be delivered to the MBTA Railroad Operations material yard in Charlestown, MA, unless otherwise directed by the Engineer. No delivery will be greater than 60 miles, one way. Such delivery of materials must be coordinated with the Engineer prior to delivery.

4.8 SITE RESTORATION

A. Below-Grade Areas: Rough grade below-grade areas ready for further excavation or new construction.

B. Site Grading: Uniformly rough grade area of demolished construction to a smooth surface, free from irregular surface changes. Provide a smooth transition between adjacent existing grades and new grades.

4.9 REPAIRS

A. Promptly repair damage to adjacent buildings, utilities, fences, or other structures caused by demolition operations.

4.10 DISPOSAL OF DEMOLISHED MATERIALS

A. Remove demolition waste materials from Project site and legally dispose of them in an EPA-approved landfill acceptable to authorities having jurisdiction.

1. Do not allow demolished materials to accumulate on-site.

2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.

B. Do not burn demolished materials.

4.11 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by building demolition operations. Return adjacent areas to condition existing before building demolition operations began.

4.12 TRACK AND TURNOUT REMOVAL AND DISPOSITION OF MATERIALS

A. Prior to track construction the existing track and turnouts shall be dismantled and removed to the limits shown on the Contract Drawings.

B. Rail, joint bars and tie plates shall be salvaged and returned to the Authority as specified in paragraph G.

C. Track bolts, nuts, washers, spikes, anchors and lags shall become the property of the Contractor and shall be disposed of off of the Authority's property.

D. Track and turnout dismantling shall be done using equipment and procedures that will not damage salvaged material or make it unfit for future use. If a torch is used to remove bolts from joints care must be taken so as not to damage joint bar.

E. All salvaged turnout material shall be packaged as a unit and delivered to designated Authority material yard(s) in Somerville or elsewhere within 50 miles of the Project, and shall be unloaded and stockpiled as directed by yard personnel.

F. All salvaged rail and other track materials shall be delivered to designated Authority material yard(s) in Somerville or elsewhere within 50 miles of the Project. Materials shall be separated, not mixed together, by class, type and weight and stockpiled as directed by yard personnel.

G. Crossties and Switch Timber - All existing crossties and switch timber removed shall become the property of the Contractor, removed from the ROW and disposed of as indicated in paragraphs I through M below.

H. Disposal shall be accomplished through incineration of ties, tie butts and switch timber and bridge timber at an approved facility.

I. The processing and disposal facility/facilities shall be fully licensed and permitted for handling, processing, storage and incineration of treated wood waste.

J. Bottom ash, fly ash, and other by-product residues from the combustion process shall be disposed of at a fully licensed land fill.

K. Identified combustion facilities must be approved by the Authority's Project Manager prior to the commencement of burning of disposed ties and timbers.

L. The Contractor shall provide the Engineer with a copy of a certified weight slip for each quantity shipped, unloaded, and properly disposed of at the licensed facility.

PART 5 - MEASUREMENT AND PAYMENT

5.1 GENERAL

A. No separate measurement will be made for demolition but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 – Railroad Grade Crossing Reconstruction, except as otherwise noted. All preparation and incidental work necessary to accomplish the removals will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 02852

GRADE CROSSINGS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. This section specifies removal of existing highway grade crossings and construction of new public grade crossings as shown on Contract Drawings.

B. Grade crossings surfaces shall be rubber rail seal and bituminous in accordance with the Contract Drawings.

C. Prior to removal of existing highway grade crossings and installation of new grade crossings the Contractor shall identify and avoid all underground utilities.

D. Prior to the removal of existing and construction of new grade crossings the Contractor shall contact DIG-SAFE. The Contractor shall also notify any fiber optic companies operating within the project limits.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 02860 – GEOTEXTILE FABRIC

1.2 SUBMITTALS

A. Submit the following to the Engineer for approval at least four weeks before the work of this Section is to begin:

1. Shop Drawings:

a. Submit the type of crossing system and the manufacturer's literature including drawings and a detailed installation specification.

B. Submit detour plans approved by City of Chelsea.

C. Submit an overall schedule and activities for the crossing reconstruction indicating a completion time within the outage agreed to with both the Authority and the jurisdictional authority.

D. All submittals will be reviewed for general conformance with the intent of the contract documents. This review will not relieve the Contractor of final responsibility for the means, methods, procedure and sequences to be utilized.

1.3 QUALITY CONTROL

A. The following Codes, Regulations, Referenced Standards and Specifications apply to work included in this Section:

1. Codes and regulations of the jurisdictional authorities.

2. AREMA: Manual of Railway Engineering

3. Manufacturer's Qualifications

a. Have rubber rail seal components of crossing systems fabricated by a manufacturer regularly engaged in the production of such items, as specified

PART 2 - PRODUCTS

2.1 MATERIALS TO BE FURNISHED BY THE AUTHORITY

A. None.

2.2 MATERIALS TO BE FURNISHED BY THE CONTRACTOR

A. Grade Crossings, General

1. Furnish an at-grade modular virgin rubber rail seal type road crossing system consisting of four rubber rail seals, one seal on both gage and field side of both rails. Area beyond rail seals and within limits of track structure shall be paved with bituminous concrete pavement.

B. Rubber Rail Seals:

1. Furnish an elastomeric type crossing material in gauge and field sections, designed and manufactured of 100% virgin rubber and having the ability to interface with a bituminous surface. All rubber materials shall meet ASTM Specification D-2000, M4A712, B35, C32, EA14, G21, and Z1 thru Z6.

2. Elastomeric type rubber rail seals, both field and gauge sections, must be capable of being installed and secured using the approved resilient fastener rail system on timber ties using 136 RE or 115 RE rail sections and the resilient fastener system furnished.

C. New treated cross ties conforming to the current AREMA Manual for Railway Engineering, Chapter 3 for 7 inch cross ties except as modified herein for grade crossings.

1. Timber cross ties within grade crossings shall be manufactured from oak hardwoods only. Crossties within grade crossings shall be 9 feet in length and shall be 7 inches by 9 inches in cross section.

2. Dimensions, with respect to measurement for size acceptance, shall not be averaged.

D. Bituminous material for roadway surfaces shall conform to the applicable Sections of the Massachusetts Highway Department Standard Specifications and the associated Special Provisions.

E. Drain pipe shall conform to the applicable Sections of the Massachusetts Highway Department Standard Specifications and the associated Special Provisions.

F. Conduits 4 inch I.D. as specified in Section 16825 – CONDUIT SYSTEMS.

1. The total quantity of conduit furnished to meet milestone dates and for crossing construction shall be in conformance with and equal to that shown on Standard plans.

G. Geotextile fabric per Section 02860 – GEOTEXTILE FABRIC.

PART 3 - EXECUTION

3.1 GRADE CROSSING RENEWAL

A. General

PART 1 - Contractor shall construct public crossings per Contract Drawings and Standard Plans 3100, 3106 and 3108.

B. Insulated Joints

1. Replacement of insulated joints for island circuits at grade crossings shall be part of the crossing reconstruction.

2. New bonded insulated joint plug rails shall be included within the new rails fabricated for the crossings. The location of these joints shall be coordinated with the signal plans.

3. New rail shall extend not less than 19 feet beyond the bonded insulated joint bar to a thermite weld made to existing rail beyond the crossing.

C. Crossing renewal shall be in accordance with the current AREMA Specifications, Chapter 9, Part 1, Standard Plans, Contract Drawings, and these Specifications.

1. The Contractor shall install a rubber rail seal and bituminous concrete pavement surface designed as specified in this Section. This type construction shall be installed according to the manufacturer's recommendations.

2. Timber crossties 9 feet in length shall be used within grade crossings.

3. Crossties shall be spaced 18 inches O.C. unless otherwise specified by the manufacturer.

4. Running rail shall be new 132 RE welded rail. Field welds are not permitted within the crossing limits.

5. Roadway surfaces shall be restored in accordance with Contract Drawings, these Specifications, and the applicable Sections of the Massachusetts Highway Department Standard Specifications.

8. A minimum of 12 inches of new stone ballast shall be provided within the pubic crossing limits between base of crosstie and top of subbase.

9. Drain pipe installation at crossings shall be per MBTA Railroad Operations Standard Drawings. Locations of drain pipe shall be as shown on Contract Drawings and Standard Plans.

10. Drain pipe installation shall include use of geotextile fabric as shown on Contract Drawings and Standard Plans. Fabric shall conform to Section 02860 – GEOTEXTILE FABRIC.

11. Motor vehicle traffic shall be controlled per the requirements of the public authority having jurisdiction over the roadway. Detour plans and closures shall be negotiated by the Contractor prior to closing crossings for construction.

12. The Contractor shall be responsible for notifying the proper authorities of work to be performed and to make all necessary arrangements required by the authorities.

D. Install conduits at crossing locations as shown on Contract Drawings, Standard Plans and as specified in Section 16825 – CONDUIT SYSTEMS.

E. Scrap metal materials shall become the property of the Contractor and disposed of off of the Authority's property.

F. Scrap crossties shall be disposed of in conformance with Section 02221 – DEMOLITION and the Special Provisions.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for grade crossings but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the work will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 02857

THERMITE WELDING

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

B. This Section includes specifications for thermite welds within turnout limits as shown on the Standard Plans and for closure welds within track where permitted by these specifications and the Engineer.

1.2 LIMITATIONS ON USE OF THERMITE WELDS

A. The Contractor shall plan and schedule the work to minimize the use of thermite welds. In general, thermite welds shall be allowed only within special trackwork, at closure welds when installing new CWR strings in existing track, when welding in plug rails at curve adjustments when a mobile welding unit is not available, and for closure welds beyond the limits of grade crossing installations.

B. Compromise thermite welds shall be allowed to join 132 RE rail to existing 115 RE rail currently in track. At these locations, the Contractor shall determine if the length of 115 RE rail being joined to 132 RE rail is less than 200 feet, resulting in a short “island: of the smaller section. In such case, provide additional new 132 RE rail, eliminating two compromise welds over a short distance.

1.3 SUBMITTALS

A. Submittals will be reviewed for general conformance with the intent of the Contract Documents. This review will not relieve the Contractor of final responsibility for the means, methods, procedures and sequences to be utilized.

B. Submittals shall be legible and reproducible.

C. Prior to initiation of thermite welding, submit detailed specifications showing proposed quick-preheat, self-tapping thermite weld kit and method and procedure for thermite welding. Specifications submitted shall comply with these Specifications and those of weld kit manufacturer.

D. Submit qualification certification for each supervisor and field welder who will perform work on this Contract. Weld supervisors and welders shall be required, upon request of the Engineer, to submit their qualification certificate throughout the duration of the project.

E. Submit name of independent testing contractor and certification that testing laboratory and persons who shall perform ultrasonic testing of field welds have previously tested a minimum of 250 welds.

F. Submit documentation that sample thermite welds have been tested and that welds meet or exceed requirements of this section.

G. Submit certified ultrasonic inspection results for field welds.

1.4 QUALITY CONTROL

A. The thermite welding process can only be successful if it is carried out by thoroughly trained and well-disciplined personnel. It will be the responsibility of the trackwork contractor to organize and coordinate all preparation and training activities for its personnel, including participation by welding kit supplier as required. Track contractor is also responsible for documenting the preparation and training activities for submittal to the Authority. Cost of all preparation and training activity shall be included in the contract line item for field welding.

B. General

1. The Contactor shall perform sample weld testing and inspection at no additional cost to the Authority.

2. Sample weld testing and inspection shall be performed by an approved certified independent testing laboratory. The Engineer may audit operations to ensure that inspection and tests are being performed in accordance with approved procedures and in compliance with these Specifications.

3. To be accepted, sample welds must fulfill the requirements of these Specifications.

C. Field Weld Qualification Inspection and Testing

1. Prior to field welding, welds and each welding crew shall be qualified as specified below. Welding crews shall prepare, in accordance with method and procedure for thermite field welding, submitted and approved under Article 1.3 of this Section, at least three samples of each type of thermite weld; high strength rail welded to high strength rail, high strength rail welded to standard rail, and standard rail welded to standard rail. Each welding crew shall perform at least one of each type of sample weld. Sample welds shall join two pieces of 132 RE rail a minimum of 30 and a maximum of 36 inches in length each.

2. Test three sample welds from each type of rail as follows:

   a. Perform Radiographic Test on all sample welds from each type of rail.
   b. Perform Rolling Load Test as specified in this Section on one sample weld from each type of rail.
   c. Perform Slow Bend Test specified in this Section on second sample weld from each type of rail.
   d. Perform Hardness Test specified in this Section on third sample weld from each type of rail.
   e. Perform Manual Ultrasonic Test specified in this Section on all sample welds from each type of rail.

3. Radiographic Testing

   a. Inspect welds radio-graphically in accordance with ASTM E142, ASTM E94, and these Specifications for purpose of detecting flaws in field welds.
   b. Radiographic tests shall detect flaws in welds with sufficient detail to establish weld's ability to meet the requirements specified herein.
   c. Radiograph four areas of each weld, head, web, and each side of base.

d. Identify each radiographic film with Contract Number, sample number, rail identity, date, welder identity, inspection agency, and view. Submit a letter of certification with each film to Engineer, giving comment on any irregularities found in the weld, and whether weld passes or fails.

e. The acceptance criteria for this test shall indicate full penetration and complete fusion with no evidence of surface or internal fissures or cracks.

f. Nondestructive inspection of metal welds by radiographic use of nuclear by-product materials shall be in accordance with United States Nuclear Regulatory Commission Rules and Regulations, Title 10, Atomic Energy, Part 20, Standard for Protection Against Radiation.

g. Transportation, handling, and storage of hazardous materials used in radiographic inspection of welds shall be performed only by, or under supervision of, a person of proven experience and ability operating under a proper license. .

4. Rolling Load Test

a. Test one sample weld from each type of rail which has passed the Radiographic Test on a 12 inch stroke rolling load machine.

b. Procedure - Mount test sample on a 12 inch stroke rolling load test machine. Apply a 57,300 pound wheel load on rail for 2,000,000 cycles. Measure and record to the nearest 0.001 inches deflection of the rail when the wheel load is over weld. Record for every 500,000 cycles.

c. Welds tested under this Article shall sustain without failure not less than 2,000,000 cycles of repeated loadings of a 57,300 pound wheel load.

d. Alternate methods of testing joint dynamically may be submitted for approval.

5. Slow Bend Test

a. Subject a second sample weld from each type of rail which has passed Radiographic Test to the Slow Bend Test described in the Proceedings of the AREMA, Volume 88.

b. Acceptance criteria for this test shall be minimum deflection of 3/4 inch and 100,000 pounds per square inch modulus of rupture.

6. Hardness Test

a. A third sample weld of each type of rail passing the Radiographic Test shall be longitudinally sectioned for a distance of one foot either side of weld, microetched, and tested by the Rockwell Hardness test using a 1 50 kg diamond sphero-conical penetrator. Test results shall be converted to Brinell Hardness Numbers.

b. Rail shall be tested for hardness on sectioned face on both sides of weld, at 1/2 inch increments on three lines until the hardness is that of parent metal. One test line will be at

center of head, second at center of web and third at center of base. Parent metal hardness shall be reached not more than 6 inches from weld center line or weld shall fail this test. The minimum Brinell number of parent metal is published as 300 for standard rail and 341 for high strength rail.

c. Inspect microetched section for compliance with field weld requirements of full penetration, complete fusion, and internal defects specified herein.

7. Manual Ultrasonic Testing

a. Inspect sample welds ultrasonically in accordance with recommendations of the Nov, 23-30, 1983 Proceedings of Association of American Railroads entitled "Railroad Rail Welding" Pages 191-205.

b. Acceptance criteria for this test shall be as specified in Article 1.4.E.4 of this Section.

8. Approval of weld kit, welding process, and welding crews will depend upon all sample welds satisfying the specified requirements. Should any sample weld fail to satisfy the specified requirements, the welding process, the welding crew, or both, will not be qualified for the work.

9. Employ a supervisor for each welding crew, who has been trained and certified for performing thermite field welding by manufacturer supplying weld kits. Should supervisor of welding crew be replaced during the work, welding crew shall be re-qualified under the new supervisor.

10. Prior to performing welds in specified work, satisfactorily qualify welds and welding crew as specified herein.

11. If Contractor changes supplier of welding kits, or welders during the job, repeat all of above sample weld testing.

D. Preparation and Training for Field Welding

1. Prior to making sample welds and prior to field welding, the Contractor shall coordinate with the welding kit manufacturer the following at no additional cost to the Authority.

a. Provide a detailed list of tools, equipment, and supplies required to make field welds. Copies shall be delivered to Contractor and the Authority and shall be kept on the job site with welders at all times.

b. Provide a detailed procedure for making field welds, consistent with Authority's requirements. Field welds shall be made with approved kits. If there are different types of welds in the Contract, for example; different sizes or types of rail and compromise joints, a procedure shall be provided for each. Copies of procedures shall be delivered to Contractor and the Authority and shall be kept on job site with welders at all times.

c. Organize and conduct training course for welders. Representatives from the Authority may also participate in course. Course shall include "hands on" experience for all students. An outline or other material describing course shall be submitted to Contractor and the Authority for review and approval. Course work shall include the different type

welds called for in Contract. All welders will participate in course, even if they have taken it for a previous job. Qualified welders will receive a dated Certification Card, signed by a Supplier Representative, approved by the Authority, which must be available for inspection at any time.

d. Organize and conduct refresher training courses for welders every six months. The Authority may participate in these courses as well. Record shall be kept by Contractor and the Authority indicating that their personnel have taken part in refresher courses. Welder's Certification Card shall be updated to reflect same.

e. Make random inspections of the welding work in progress, at least every three months, to insure that proper tools, equipment, and supplies are being used, and that their procedures are being followed.

f. The welding kit manufacturer shall be on call to assist the Contractor and the Authority in case any unusual problems arise in the field. Supplier should be prepared to provide for laboratory testing needed to solve a problem, and should have the capability of tracking their kit materials backward through the chain of production.

2. Responsibilities of the Contractor Coordinate welder training program described above, including provision of documentation required by the Authority to describe course, and verify that Contractor's personnel have successfully completed course work.

E. Field Weld Record

1. Contractor shall provide the Authority with a complete and up-to-date record of all welds, welders, and welding kits. This record shall be submitted on the approved Authority standard form which includes, but is not limited to, the following information for each weld.

a. Weld number, location by track designation and station, date and time weld made
b. Rail identification including section, heat number, date rolled
c. Kit manufacturer and identity of each mold and portion
d. Weather conditions, air and rail temperature
e. Rail gap
f. Name of welder, Contractor's foreman, and MBTA representative on the job

2. A copy of approved Authority form Figure 02857-3 has been made part of this Section.

F. Field Weld In-Track Testing

1. During field welding, hand test and inspect all field welds as specified herein to ensure compliance of welds to requirements of these Specifications.

a. Thermite welds shall be visually and dimensionally inspected as soon as weld has been completed regardless of whether track has been designated as "in revenue service" or "out of revenue service."

b. Manual ultrasonic testing of thermite welds in track designated as "in revenue service" shall be completed within 24 hours of weld completion.

c. Manual ultrasonic testing of thermite welds in track designated as “out of revenue service" shall be completed within 30 days from date of welding but in all cases prior to the resumption of train operations.

d. It shall be the responsibility of the Contractor to follow above criteria and ensure that all welds are properly inspected and tested at no additional cost to the Authority.

2. Manual Ultrasonic Testing

a. Inspect all field welds ultrasonically in accordance with recommendations of the Nov. 29-30,1983 Proceedings of Association of American Railroads entitled "Railroad Rail Welding" pages 191 -205. Weld quality shall meet requirements of this Section.

b. For each field weld, complete and submit the MBTA Ultrasonic Test Report attached to the rear of this Section as Figure 02857 – 2.

3. Test Procedures – Ultrasonic

a. Testing organization shall submit to the Authority detailed test procedure and description of test equipment including calibration blocks that will be utilized in testing process. Calibration process shall be able to permit detection of any defect including the size, type, and location. Test procedure and equipment shall include, but not be limited to the following:

1) Calibration:

- Calibrate when starting work and at least every hour.
- Recalibrate if there is a change in probes or cables.
- Use I.I.W. Type 1 and Type B-1 steel test blocks for calibration. A rail with drilled holes may be used in addition. If a rail is used, a duplicate shall be provided to the Authority.

2) Web Test:

- Use two 45 degree probes placed on top of rail in pitch-catch configuration.
- Scan from top to bottom of weld with both probes.
- Scan top and bottom edges of weld with a single probe.
- Scan from both sides of weld.

3) Head Test:

- Use two 45 degree probes placed on sides of the rail head in pitch-catch configuration.
- Scan across weld with both probes angling them up and down to cover entire cross-section of weld.

- Scan each vertical edge of weld with a single probe.
- Scan from both sides of weld.

4) Base Test:

- Use a 70 degree probe,
- Place probe on top of base far enough back from center of weld so that beam is following the "3/4 W" path.
- Move toward and away from weld, angling probe from side to side.
- Scan both sides of base and from both sides of weld.

b. Test crew shall fully document their findings, on approved Authority standard form. This form shall include, but is not limited to, identification of: test equipment used, calibration, weld number and location, members of test crew, date and time of test, description of defects, and recommendation to accept or reject weld. The Authority approved form Figure 02857-2 has been made a part of this Section.

4. Acceptance Criteria – Ultrasonic

a. No defect in the weld of any size will be accepted in the head, web or base of rail.

b. Authority Materials Testing Lab may perform random manual ultrasonic tests of field welds. The Authority is currently using equipment supplied by Krautkramer, and personnel who have been trained with this equipment.

5. Physical Inspection

a. Contractor shall visually and dimensionally inspect each field weld to determine conformance with alignment and finishing tolerances specified herein.

b. When weld is made and molds and risers removed weld shall be checked for obvious failures such as an incomplete weld.

c. Once weld has been ground and weld temperature is less than 200 degrees F, physical inspections shall be made to verify acceptance criteria.

6. Acceptance Criteria – Physical

a. There should be no visible voids, ratholes, nicks or gouges in surfaces which have been ground.

b. Weld collar in web zone and base of rail should not be ground except to remove notches created by upset conditions. Sharp protrusions and gouges should be blended into rail and weld collar contour to eliminate possible stress risers.

c. Combined vertical offset and crown camber at top of rail, at rail temperature of200 degree F or less, shall not exceed 0.060 inches, measured as shown on Figure 02857-1. NO DIP CAMBER will be allowed.

d. Combined horizontal offset and horizontal kink camber at side of rail head, at rail temperature of 200 degree F or less, shall not exceed 0.060 inch, as shown on Figure 02857-1.

e. A finished deviation of not more than plus 0.010 inch or minus 0.00 inch from parent section of rail head surface shall be allowed.

f. If field weld, because of certain field conditions, is located within 4 1/2 inches of a rail support, the sides and bottom of the rail base shall be within plus 0.012 inch or minus 0.00 inch of parent section.

g. Weld straightness tolerances shall be as shown on attached Figure 02857-1.

7. Defective Welds

a. Defective welds shall be cut out and replaced with a 19 foot 6 inch section of new rail, welded in place, at no additional cost to the Authority.

8. Final Ultrasonic Testing

5) Final ultrasonic testing shall be performed by an on track detector car

PART 2 - PRODUCTS

2.1 MATERIALS TO BE FURNISHED BY THE AUTHORITY

A. None.

2.2 MATERIALS TO BE FURNISHED BY THE CONTRACTOR

A. Furnish complete thermite weld kits conforming to attached MS No. 9266 and this Section.

B. Furnish compromise thermite weld kits designed to join 132 RE rail to 115 RE rail.

PART 3 - EXECUTION

3.1 THERMITE WELDING

A. General

1. Thermite field welds shall be made to join rails within turnout limits as shown on the Standard Plans and as specified in Article 1.2 of this Section.

2. Ends of rails to be welded shall be saw cut. Torch cutting of rails will NOT be allowed.

3. Do not locate field welds within the following locations in standard track work:

    a. Within 8 feet of the center of any bolted, bonded, or insulated joint.
    b. Within 2 feet of a thermite weld in the opposite rail.
    c. Within 6 inches of any hole drilled in rail.
    d. Within 9 inches of a weld which has been cut out.
    e. Over a tie plate.
    f. Within a grade crossing.

4. In the case of special trackwork (turnouts and rail crossings) some exceptions to above will be allowed, with approval of the Engineer.

5. If plug rails are required to meet requirements shown above, or to replace a defective weld, minimum length of plug rail is 18 feet.

6. Thermite welding process generates extremely high temperature (up to 5000° F) accompanied by flames, sparks, hot molten metal, and slag. Extreme caution shall be observed by welders and others in the vicinity. The following precautions must be observed.

    a. During welding process, prevent hot molten metal and slag from contacting water, snow, or ice as an explosion could occur.
    b. Properly dispose of hot slag, slag pans, top and side risers, or other hot scrap. Be sure that this material is not left where it could be stepped on, causing serious injury.
    c. Wear welding goggles or safety glasses and other safety equipment as appropriate.
    d. During and after welding, avoid burning or damaging rail pads, ties and timbers, or setting fire to wayside areas. A fire extinguisher shall be required at weld site (2 1/2 gallon water type extinguisher).
    e. Keep welding tanks, hoses, and other flammables a safe distance from the weld site.
    f. Do not make field welds on open deck bridges or timber structures.
    g. Unused thermite material must be kept in an approved secure, dry, weather tight location, consistent with applicable fire regulations so that it will not be accessible to unauthorized persons.
    h. When welding rails in track on lines in service, be sure that rail fastenings, anchors or clips, pads, and insulators, are properly installed prior to restoration of service.

B. Weld Quality

1. Weld quality shall be as specified in Article 1.4 of this Section.

C. Welding Requirements

1. Use approved kits that are self-tapping and require minimum preheating.

2. Saw-cut rail ends at right angles to rail. Clean the surface of rail for a length of approximately six inches from each end, free of all grease, dirt, loose oxide, scale and moisture. Remove burrs and lipped metal which would interfere with the proper fit of molds.

3. At time of field welding, rails shall be aligned to produce a weld which, with respect to alignment, shall be in accordance with Article 1.4.E.6 of this Section.

a. Proper rail end alignment shall be achieved by use of an approved alignment device designed and manufactured for this purpose. In no case will use of track jacks or track spikes be allowed for rail end alignment.
b. Striking of rail with blunt tools, such as a maul, is prohibited.
c. Contractor shall assure that rail ends are secured against longitudinal, vertical, lateral or twisting movement during and immediately after the welding process. Rail puller/expanders shall be used to prevent movement. Rail clips or anchors shall be installed if there is a chance of longitudinal movement.
d. At time of field welding, rail gap shall be as specified by manufacturer of the weld kit.

4. The following restrictions limit when field welds can be made, and specify special procedures required under certain environmental conditions.

a. Field welds shall not be made when the ambient temperature is below 32°F and during inclement weather such as rain, mist, sleet, and snow unless approved by the Engineer.
b. It is important that weld is not subjected to a sudden strain by-releasing hydraulic pressure too quickly. The rail puller/expander shall be left in place until rail has cooled to below 500 degrees F. Any movement of rail before weld has cooled to at least 500 degrees F. may result in failure of weld.
c. b. Hydraulic rail puller/expander shall not be used to establish proper rail end gap.
d. When welding rail in track on lines in service, allow sufficient time to complete weld so that surface finish and temperature of welded joint will permit safe operation of scheduled trains without delay to service. Temperature of welded joint should be 200 degrees F or less before rail traffic is allowed to pass over weld.
e. Thermite field welds shall be made in accordance with and shall not deviate from manufacturer's recommendations and AREMA Chapter 4. Short cuts in recommended pre-heating process are prohibited.

5. Trim and grind weld to meet the following requirements and as otherwise specified by manufacturer:

a. Finish weld to the tolerances specified in Article 1.4 of this Section.
b. A rail shear, specifically designed for the purpose, shall be utilized to remove weld upset. Use of a saw, cutting torch or other hand held devices is prohibited.
c. Rail profile grinder specifically designed for the purpose, shall be utilized to finish grind top and sides of weld. Use of hand held grinder is prohibited.
d. As specified in Article 1.4.E.6.b of this Section, weld collar in the web zone and base of rail should not be ground except to remove notches created by upset conditions, sharp protrusions, and gouges. These should be blended into the rail and weld collar contour to eliminate possible stress risers. Remove, by grinding, defects visible to the unaided eye. If removal by grinding cannot be accomplished without damaging rail, remove the weld. Take precautions to avoid excessive pressure during grinding of weld in order to prevent overheating of rail surface.
e. Finish grinding shall be done only when weld temperature is less than 200 degrees F.
f. Overheating rail when grinding must be avoided. Since weld has cooled to below 200 degrees F. prior to grinding, the temperature rise due to grinding should not exceed this level.

g. Finish rail grinding on top and sides of weld shall be completed prior to operation of trains over weld.

D. Weld Identification

1. Mark weld identification on field side of rail using a permanent metal marker as manufactured by J,P. Nissen, Jr. Co., or approved equivalent and record required information in conformance with Article 1.4.D.

E. Weld Cleanup

1. Clean up and remove waste material such as paper and plastic containers, scraps of metal, slag, and molds.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for thermite welding but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the work will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 02860

GEOTEXTILE FABRIC

PART 1 – GENERAL

1.1 DESCRIPTION

A. This Section specifies furnishing all labor, material, tools, and equipment to install geotextile fabric at underdrains specified in Section 02852 – GRADE CROSSINGS and as shown on Contract Drawing and Standard Plans.

1.2 SUBMITTALS

A. Submit manufacturer's certification for review stating that the geotextile fabric fulfills the specification criteria set forth in this section.

B. All submittals will be reviewed for general conformance with the intent of the contract documents. This review will not relieve the Contractor of final responsibility for the means, methods, procedures, and sequences to be utilized.

PART 2 – PRODUCTS

2.1 MATERIAL

A. Geotextile fabric shall be polypropylene or polyester non-woven, continuous filament meeting or exceeding the following properties:

PROPERTY	TEST METHOD	MIN. VALUE
MECHANICAL		
Tensile Strength (grab)	ASTM D 4632	115 lbs.
Elongation	ASTM D 4632	50%
CBR Puncture	ASTM D 6241	310 lbs.
Trapezoidal Tear	ASTM D 4533	50 lbs.
UV Resistance	ASTM D 4355	70%
HYDRAULIC		
Apparent Opening Size	ASTM D 4751	70 US Std. Sieve (Max Value)
Permittivity	ASTM D 4491	1.7 Sec^{-1}
Water Flow Rate	ASTM D 4491	135 gpm/ft^2

2.2 SHIPMENT AND STORAGE

A. During all periods of shipment and storage, the fabric shall be protected from direct sunlight, ultra-violet rays, temperatures greater than 140 degrees F, mud, dirt, dust and debris.

PART 3 - EXECUTION

3.1 CONSTRUCTION METHODS

A. Fabric installed at public highway crossings shall encapsulate the stone ballast and prevent fouling of the perforated underdrain with fines in conformance with Standard Plan 3106 and the Contract Drawings.

B. The surface receiving the fabric shall be prepared to a relatively smooth condition, free of obstructions, depressions, debris and soft or low-density pockets of material.

C. The method of installation shall ensure that any resulting tears in the fabric shall be repaired by placing an additional layer of fabric over the tear.

D. Ballast shall be carefully placed onto the fabric to avoid damaging the cloth. No more than five days should elapse between exposing the fabric and covering with ballast. Construction or other vehicles shall not travel over the fabric.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for geotextile fabric but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the work will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16800

ABBREVIATIONS AND DEFINITIONS

PART 1 – GENERAL

1.1 SCOPE

A. Wherever in the Specifications or Contract Drawings the following terms are used, the intent and meaning shall be interpreted as herein defined.

B. Pertinent provisions of the following listed standards shall apply to the work of this Specification, except as they may be modified herein, and are hereby made a part of this Specification where the requirements of the following do not conflict with this Section of the Specifications.

1. American Railway Engineering and Maintenance-of-way Association (AREMA) C&S Manual Part 1.1.1 Specification of Technical Terms Used in Signaling.

2. Institute of Electrical and Electronic Engineers (IEEE) Standard Dictionary of Electrical and Electronics Terms.

C. In the event of a conflict between definitions, the following order of priority shall be followed:

1. Definitions as contained herein.

2. AREMA C&S Manual Part 1.1.1

3. lEEE Standard Dictionary

1.2 DEFINITIONS

AREMA (Formerly AAR)

American Railway Engineering and Maintenance-of-Way Association, 10003 Derekwood Lane, Lanham, MD 20706

Alarm Condition

Any abnormal condition which requires the attention of an attendant or operator.

Audible Alarm

The sounding of a bell, buzzer, or other acoustic device to draw the attention of the Control Operator to an alarm condition.

AWG

American Wire Gauge

Authority

Massachusetts Bay Transportation Authority (MBTA).

AREMA Signal Manual

American Railway Engineering and Maintenance-of-way Association Signal Manual of Recommended Practice.

Automatic Local Control

A mode of system operation in which functions such as route initiation and dispatching are automatically performed by local equipment.

Automatic Routing System

A system to automatically establish route selection at a control point to permit the routing of trains in accordance with a pre-determined schedule or other method of automatic route selection.

Automatic Train Control (ATC)

The system for automatically controlling train movement, enforcing train safety, and directing train operations. ATC includes subsystems for Automatic Train Protection, Automatic Train Supervision, and Automatic Train Operation.

Automatic Train Operation (ATO)

The subsystem within Automatic Train Control which performs the on-train functions of speed regulation, program stopping, and performance adjustment.

Automatic Train Protection (ATP)

The subsystem within Automatic Train Control which maintains safe train operation. ATP subsystems include train detection, train separation, interlocking, and speed-limit enforcement.

Automatic Train Supervision (ATS)

The subsystem within Automatic Train Control which monitors and provides controls necessary to direct the operation of a system of trains in order to maintain intended traffic patterns and minimize the effects of train delays on the operating schedule.

Auxiliary Switch Operation

A manual control which permits operating a switch movement without clearing a signal.

Ballast Impedance

The total inter-rail impedance caused by electrical leakage paths of a given section of electrically isolated unoccupied track.

Ballast Resistance

The total inter-rail resistance caused by electrical leakage paths of a given section of electrically isolated unoccupied track.

BCH

(BOSE-CIIAUDHURI-HOCQUENGHEM) The cyclic codes of Bose-Chaudhuri colics that is particularly effective in the detection and correction of randomly occurring errors.

Block

A length of track of defined limits, the use of which by trains is governed by block signals.

Bootleg

A protection for track wires where the wires leave the ground near the rail.

Bus

A conductor or a group of conductors, that are terminated as a common connection for two or more circuits.

Call-On Signal

A wayside signal aspect authorizing a following train movement into an occupied block, with the route lined and locked.

Central Control Office

A location from which the functions of a traffic control system or of interlockings are controlled.

Central Instrument House (CIH)

A large walk-in type housing, sometimes called a bungalow or Signal Instrument House; which is used to house signal equipment and terminate cable at an interlocking or control point.

Channel Bank

A device which samples, quantisizes, and codes/decodes voice frequency or data circuits into/from a digital pulse code modulation (PCM) signal.

Circuit, Vital

Any circuit which affects the safety of train operations.

Civil Speed Limit

The maximum speed allowed in a specified section of track as determined by physical limitations of the track structure, train design, and/or passenger comfort.

Commuter Rail Operations Control Center (CROCC)

Train Dispatcher and Trouble desk center for commuter rail operations system wide. Somerville, MA. (Trouble Desk # 617 222-3628)

Constant Warning Time Track Circuit

Constant warning time equipment has the capability of sensing a train in the approach section, measuring its speed and distance from the crossing and activating the warning equipment to provide the selected minimum warning time.

Control(Supervisory)

A coded message from a control console to a field location to change the status of signal equipment for train operation.

Controlled Signal

A block signal located at a control point arid capable of being controlled by a control operator, dispatcher (home signal).

Control Point

A location so designated where signals, switches, traffic direction and/or other functions of a traffic control system are controlled either locally or from a central control office. (Interlocking)

Crossover

Two turnouts, with track between the frogs, arranged to form a continuous passage between two tracks.

Crosstalk

Undesirable interference created by coupling between one system and another system or from one portion of a system to another portion of the same system.

Data Circuit

A digital signal which conforms to the RS-232-C standard for serial transmission at a baud rate of 300-9600, or a formatted signal for direct digital input to a channel bank at speeds up to 64 Kb/s.

Data Transmission System (DTS)

A bi-directional digital communications system between Central Control and field, or other, locations.

Derail

A device designated to cause rolling equipment to leave the rails (AREMA). Derails are either "split-point" type or "lifting-block" type.

Dragging Equipment Detector (DED)

A device installed in the track area to detect the presence of an object extending below the top of rail hanging from a moving train.

DS-1

A digital pulse code modulated (PCM) bipolar signal operating at 1.544 Mb/s to Bell/USITA TA34 requirements, comprised of 24 multiplexed voice frequency or data circuits.

DS-3

A digital signal (either electrical or optical) operating at 44.736 Mb/s, comprised of 28 multiplexed DS-1 signals.

Digital Signal CrossConnect (DSX)

A jackfield for the cross connection of circuits at the DS-1 level.

DTS

Data Transmission System

Downstream

For a given direction of travel, locations beyond a specified reference point. Used interchangeably with AAR term "in advance of.

Engineer

Wherever on the Contract Drawings or in the Specifications the term Engineer is used, it shall mean the Resident Engineer or other duly authorized representative of the MBTA.'

EPROM

Erasable programmable read only memory.

Fiber Distribution Panel

A rack mounted device for the connectorized mating of fiber optic pigtails and the mounting of wave division multiplexers (WDM).

Fleet

A method of route control in which a route request and establishment is not cancelled by the passage of a train.

Floodgate

A controlled water-barrier track gate that can be closed across the track(s).

FRA

Federal Railroad Administration

Hertz (Hz)

The unit of frequency in cycles per second.

Housings

A signal instrument house, shelter, wayside case, junction box etc.

Indication (Supervisory)

A coded message from a field location to a control console to report the status of signal equipment or train operation.

Insulated Joint

A rail joint in which electrical insulation is provided between adjoining rails.

Interface

The interconnection or Inter-relationship between two or more systems, subsystems, persons, or contracts, required to ensure continuity and proper operation.

Interlocking

An arrangement of signals and signal appliances operated from an interlocking machine and so inter-connected by means of electric locking that their movements must succeed each other in proper sequences, train movements over all routes being governed by signal indication.

Interlocking Limits

The length of track or tracks between opposing way side signals controlled by an interlocking.

ICEA

Insulated Cable Engineers Association

Joint Electron Device Engineering Council (JEDEC)

Cooperative effort of Electronic Industries Association (E1A) and National Electrical Manufacturers Association (NEMA).

Junction

A location where train routes converge of diverge.

Live work

Signal or Electrical work that is vital to the operations of the Rail Road. Live work shall be done by the Operating RR.

Local Distribution Frame (LDF)

A small or medium sized cross-connect aid common termination point for voice frequency and data copper cables which is subordinate to the main distributing frame (MDF). from which all local voice frequency and data circuits shall be accessible.

Local Manual Control

A mode of system operation in which functions such as route initiation and dispatching are controlled manually by local equipment.

Locking

The electrical or mechanical establishment of a condition for a switch, interlocked route, speed limit, or automatic function which cannot be altered except by a prescribed and inviolate sequence of unlocking.

Main Distributing Frame (MDF)

A medium or large sized cross-connect and common termination point for voice frequency and data copper cables from which all voice frequency and data circuits shall be accessible.

Married Pair

Two cars, semi-permanently coupled together, which share certain common equipment.

Master Display Panel (MDP)

A diagrammatic track model, in a central control facility, including status indications for switch position, signals, and track occupancy.

Maximum Authorized Speed (MAS)

The highest speed limit which is authorized.

Mean Time Between Failures (MTBF)

The average time that a piece of equipment will operate without a failure.

Mean Time to Repair (MTTR)

The average time required to restore a piece of equipment to operation after the report of a failure. This time is measured from the time troubleshooting and repair work begins until restoration is complete.

Multiplexer Demultiplexer (MULDEM)

A device for combining a number of individual low speed digital channels into a common high speed digital bit stream for transmission over digital facilities.

Manual of Uniform Traffic Control Devices, (MUTCD)

Part 8, Traffic control for railroad and light rail transit grade crossings.

Noise, Electrical

Interference brought about by undesirable random voltage or currents.

Operating Railroad (OPRR)

The company providing services to the MBTA for operations of the railroad system which is currently Massachusetts Bay Commuter Rail (MBCR).

Outside Plant (OSP)

Any device or apparatus intended for permanent installation in a non-protected, exposed environment.

Pothead

A method of protecting cable ends from the weather and to provide means of disposing of static stresses set up at cable ends.

Power-Bond

A conductor of low resistance providing a path for return of propulsion current at non-insulated joints, frogs, and switch points.

Railroad

The operating railroad for the MBTA N/F Massachusetts Bay Commuter Rail (MBCR).

RAM

Random Access Memory

Rapid Information Retrieval System

A static informational data-bank accessed manually.

Reaction Time

The time used by equipment, operator, or both, that elapses between the moment an action is called for and when the desired result occurs.

Remote Terminal Unit (RTU)

The equipment which constitutes the field end of a Data Transmission System.

Right-of-Way Hazard

The existence of an abnormal condition, on, or near, the tracks which could impair safe train movement.

Route

A specified succession of contiguous blocks over which trains operate between two controlled interlocked signals.

Service Brake

Retardation produced by the primary train braking system.

Signal

An appliance which conveys information governing train movements, either in a stationary wayside location or in a mobile vehicle-mounted location, responsive to dynamic information based on train position.

Signal Aspect

The appearance of a fixed signal conveying an indication as viewed from the direction of an approaching train; the appearance of an automatic speed control cab signal indicator as viewed in the cab.

Signal Indication

The information conveyed by the aspect of a signal.

Signal Instrument House (SIH)

A large walk-in type housing, sometimes called a bungalow or central Instrument House; which is used to house signal equipment and terminate cable at an interlocking or control point.

Signal Instrument Room (SIR)

Room located in tower or buildings or at other strategic points to house wayside equipment, also known as and interchangeable with Relay Room, or Central Instrument Room.

Snow Melter (SM).

An electric, gas. or hot air heater or element used to melt snow and ice at designated locations to allow proper operation of equipment.

Station Distribution Frame

A Local Distribution Frame (LDF) installed within a station communication room.

Subsystem

A subsystem comprises elements within a system which are interconnected to perform a specific function.

Switch-and-Lock Movement

A device which performs the sequential functions of unlocking, operating, and locking a track switch (Switch Machine)

Switch (Electric)

A device by means of which an electric circuit may be opened or closed.

Switch (Track)

A pair of switch points with their fastenings and operating rods providing the means for establishing a route from one track to another.

Switch Circuit Controller

A device for opening, closing or shunting electrical circuits, operated by a rod connected to a switch point.

Switch Point

A movable tapered track rail, the point of which is designed to lit against the stock rail.

Terminating Shunts

Tuned electrical shunts which define the approach end limits of motion sensitive track circuits.

Track Transformer

A transformer designed to couple electrical energy to and from the rails of a track circuit.

Track Circuit

An arrangement of electrical and/or electronic equipment, including a length of the running rails, which permits detection of trains within the limits of the running rails.

Traffic Circuit

A circuit which controls and maintains the direction in which a signal system will accept and govern train movements.

Traffic Control System

A block signal system that permits trains to operate in both directions on the same track governed by the indications of block signals. Automatic Block Signal System Rules and Automatic Train Stop rules apply. The limits of Traffic Control system territory shall be designed cither in RULES for Employees or by Special Instructions.

Tradable Swatch Operating Layout

A device which performs the functions of operating a track switch. It can operate the track switch either in a motor driven mode, or can be trailed through by a train.

Train Control Rooms (TCR)

Rooms located in buildings or at other strategic points to house wayside equipment; also known and interchangeable with Relay Room.

Train Detection Equipment

The track circuits and associated equipment used to detect the presence of trains.

Train Identity

The alpha-numeric code assigned to each train which contains, as a minimum, the elements of train destination, direction, and train number.

Train Shunt Impedance

The electrical impedance between running rails when spanned by train wheels and axles.

Turnout

An arrangement of a track switch and frog with closure rails that provides tire means for rolling stock to be diverted from one track to another.

Uninterruptible Power System (UPS)

An auxiliary power system which provides an uninterrupted AC power source during a normal power source failure.

Unsafe Condition

Any condition which endangers human life or property.

Upstream

For a given direction of travel, locations which have been passed prior to reaching a specified reference point. Used interchangeably with AREMA term "in approach of."

VMIS

Vital Microprocessor Interlocking System

Voice Frequency (VF)

An analog alternating current signal suitable for voice transmission with a bandwidth of 4-kilohertz.

Walkways

Paved pathways between yard tracks for the purpose of accommodating personnel and equipment engaged in operational servicing of cars.

Wayside Case

Housing located along the right-of-way, used to house signal apparatus and/or terminate underground or aerial cable.

Yard Control Console

A modern multi-system console type desk on which are mounted signal control and communication facilities for control of yard signal and switching functions.

Yard Lead

A portion of track connecting a yard storage and/or service area with the mainline.

END OF SECTION

SECTION 16801

BASIC TECHNICAL REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the basic requirements for work to be performed by the Contactor to furnish and install wayside signal, communication and power systems equipment and materials at locations.

B. Performance of the work as well as provision of any and all associated equipment and materials shall comply with the latest versions of MBTA Commuter Rail Design Standards (CRDS), MBTA Track and Roadway Standards, Manual of Uniform Traffic Control Devices (MUTCD) and American Railway Engineering and Maintenance of way Association (AREMA). In the event of conflict between a referenced standard(s) the most stringent shall apply as determine by the Engineer.

C. The basic intent of this Contract is to relocate and remove existing wayside signal, , cable and equipment and grade crossing gates and flashers throughout the project limits as shown in the Contact Drawings and described in this Specification.

D. The Contractor shall install the equipment to meet all schedule dates and milestones as shown on the schedule. The Contractor will be required to be flexible. Schedule dates may shift due to long lead equipment deliverables, routines or emergencies of the active railroad operations

E. Operating Railroad personnel will connect or disconnect any and all working wires, cables and equipment. The Contractor will NOT work on any live signal circuits or working equipment except under the direction of the Operating Railroad.

General

1. The bulk of signal materials, equipment, hardware and appliances to be installed will be furnished by the contractor.

2. The Contractor and sub-contractors will only work with the permission and under the supervision of the Operating Railroad flagman or designated representative.

3. All equipment, hardware and appliances to be installed shall be new. No removed, relocated, or refurbished materials shall be used without the consent of the Engineer.

4. If there is a conflict between contract specifications and contract drawings, the MBTA's Engineer will determine the correct action:

Overview

1. Below summarizes significant Contractor responsibilities and requirements.

a. The Contractor will install (trench, plow, hand-dig as required) cables, depicted on the contract drawings. Conduit systems will be required where cables cross grade crossings, under tracks, where required depth cannot be obtained, etc. The Contractor will be responsible for the conduit system design. As track and site work progress, field conditions may necessitate additional hand holes and conduit systems. Typical drawings have been provided. The contractor shall propose the method of traversing these obstacles to the Engineer for acceptance prior to construction. Express cable shall not be spliced. Every effort shall be made to run continuous lengths of cable between points. If cable lengths cannot accommodate required lengths, then junction boxes for terminations shall be used as specified in Section 16840.

b. Furnish, assemble, and install all highway grade crossing signals and their associated foundations as depicted on the contract drawings

c. The Contractor shall provide only experienced personnel to safely work within the railroad envelope of operations i.e.; active rail lines, functioning wayside signals, cable, housings, junction boxes, overhead wires high voltage electrical circuits, equipment and obstructions. Contract personnel should be capable of assembling, wiring, tagging and installing signal appliances.

d. All hosting and rigging work shall be performed by qualified licensed personnel with a safe working record.

e. The Contractor is responsible for assuring that every employee or subcontractor working on this project and on railroad property has successfully completed railroad safety training and understand the requirements thereof.

f. The work shall include the temporary and permanent track connections, rail bonding, insulated joints, crossing (termination) shunts and track work requirements necessary to install new and maintain the existing signal system.

g. Signal equipment locations (coordinates) are as shown on the signal line plan contained within the contract documents.

h. Contractor shall provide as built location plans of all cables installed. Plans shall be marked to reflect actual location of trenching and cabling as demonstrated by distance from center line of track and other quantifiable methods.

i. Contractor shall provide excavation for foundations, conduits, direct bury cables, junction boxes, hand holes, trough, manholes, rail connections, and removal of retired equipment. Backfilled areas will be checked every 2 weeks and refilled as necessary until settlement stops.

j. Operating Railroad approval is required for open ditches, trenches and holes that will be left unattended. Appropriate safe guards shall be used to prevent accidents such as stakes and danger tape, snow fence etc.

k. After completion of installation of ground materials, Contractor shall level and grade entire work site to allow safe vehicle and foot traffic. Contractor will revisit finished sites on two week increments to ensure there is no settling of earth work and ensure hazardous situations are eliminated. Refill settled areas every two weeks until settlement stops

l. Contractor shall be responsible for all equipment and tools used on the project to be safe and proper for work to be accomplished and shall meet or exceed OSHA standards.

m. At all times Contractor will adhere to the direction of the railroad flag-person and signal/track and electrical personnel.

n. Prior to work at a particular location, discussion with the crew and railroad personnel shall take place to identify potential hazards.

o. The Contractor is required to pothead cables, terminate, and test, coordinate with the Operating Railroad signal, communications and electrical personnel and as directed by the Engineer.

p. Contractor is required to obtain dig-safe tickets prior to all excavations

q. Contractor shall perform all testing as required in specification section 16898 and be approved by the Engineer, prior to the release to the Operating Railroad for operational testing and commissioning.

r. Contractor shall perform wiring modifications and installation of required equipment to existing, in-service automatic and home signal locations for the limits of the project as depicted on the Single Line drawings, as well as other existing locations to facilitate phased activation of grade crossings and signal system cut-overs with plans to be provided by the Engineer during construction.

s. All retired equipment shall be removed and disposed of properly. Any equipment deemed salvageable by the engineer or Operating Railroad shall be brought to a predetermined site. Any equipment the Operating Railroad determines is not salvageable; it shall be the Contractor's sole responsibility to dispose with properly. These locations shall not be left in a hazardous condition. Holes shall filled in, power lines shall be disconnected and removed, tripping hazards shall be removed, and any other actions required to alleviate any safety concerns at the site as determined by the Engineer.

2. Highway-Rail Grade Crossings

a. Contractor shall install conduit(s) as shown on contract drawings. MBTA Standard Plan 3100 shall be followed. Conduits should extend under the tracks 57 Feet from each edge of road. Adjustment to this standard plan may be required to suit actual field conditions as shall be approved by the Engineer

b. Contractor shall install cables as shown on contract drawings and documents as prescribed by MBTA (CRDS), AREMA, NEC and manufacturers recommendations.

c. Contractor shall relocate crossing signals including all gate, flasher, and furnish and install new foundations as shown on the contract drawings.

d. Contractor shall re- assemble all required parts to complete crossing signals and cantilevers then wire, tag, terminate and mount on new foundation as shown on the contract drawings.

e. Contractor shall install signal housing cable entrances as shown on the contract drawings.

f. Contractor shall support the Operating Railroad with the phased activation of the new crossing signals. This work shall include installation of temporary interface cables between existing and new signal housings and the crossing signals as required.

3. Wayside signal locations

a. Contractor shall install conduit(s) as shown on the contract drawings.

b. Contractor shall install cables as shown on contract drawings and documents as prescribed by MBTA (CRDS), AREMA, NEC and manufacturers recommendations.

c. Contractor shall remove wayside signals including their foundations as shown on the contract drawings.

4. Qualification

a. The Contractor qualifications shall include a list of related completed projects, resumes of key personnel and references. The Contractor shall demonstrate credentials of having successfully completed similar projects. Key personnel shall have a minimum of ten years of acceptable experience in rail / transit signaling, communications and electrical work.

b. The Contractor shall employ a qualified on-site railroad Signal Engineer for the duration of the Project to direct the installation of the signal, and communication work as described herein until final acceptance by the Authority. The Signal Engineer shall be responsible for all work performed during this Contract and shall provide written verification of all inspections and tests performed as being personally witnessed and correct.

c. The Contractor shall employ a qualified signal design engineering firm to perform all of the tie-in work, detailed wiring, staged cut-overs, testing and commissioning of the grade crossing and as required to remove the automatic signals and “long block” between interlockings.

d.

1.2 DELIVERY, STORAGE AND HANDLING

A. Any equipment damaged, lost or stolen shall be replaced by the contractor at no additional cost to the contract. The Contractor shall provide a safe and secure materials/delivery storage site and provide a structure for weather sensitive materials. This site should be located within the project limits.

B. Deliver all hardware, components, accessories and documentation to the work site or other designated area as approved by the Engineer.

1. Provide adequate bracing and enclosures to protect equipment from damage during shipping and handling. Inside storages shall be provide for protection of equipment not ready for immediate installation upon delivery

2. Identify all shipments and individual items with the Contract number and destination.

3. All Shipments shall be inspected by the Contractor at the time of delivery and verified that all the items are not damaged and are in working condition.

4. The security of the equipment and materials that require on-site storage for construction staging shall be the responsibility of the Contractor

1.3 SITE CONDITIONS

A. The Authority believes that the information on the Contract Drawings describing the existing signal facilities pertinent to this Contract is correct insofar as it is shown; however, it does not guarantee or represent that the existing signal facilities conform to the Contract Drawings. It shall be understood that conditions may exist which are contrary to the conditions indicated by the existing system plans and that the Contractor assumes all risks regarding the cost or quantity of the work to be done because of any use of which he may make of them. The Bidder shall visit the site and satisfy himself by visual inspection alone, as to existing conditions. No claim for extra cost or time extension will be allowed by the Authority because of the Contractor's unfamiliarity with observable site conditions

B. Dust, dirt, varying climatic conditions and electrical interference shall be considered and reflected in implementing the installation of all systems, subsystems, equipment and components.

1.4 PHASING REQUIREMENTS

A. The project shall be completed in phases implemented by the MBTA in accordance with the approved contract schedules and the requirements of other sections of these Specifications.

B. Phasing may be impacted by progress of the project and availability of equipment and materials. Contractor will be required to be flexible in work locations due to long lead equipment deliverables, routines or emergencies of the active railroad operations. As phasing plans are developed contingent on work progress the contractor shall submit all phasing plans to the Engineer for approval.

1.5 REGULATORY ELECTRICAL REQUIREMENTS

A. The Contractor shall comply with the electrical requirements of all national, state and local codes, laws and ordinances, and all rules and regulations of public administrative authorities having jurisdiction over the work where the requirements do not conflict with these Specifications.

B. The latest published issues of the standards, codes, recommendations or requirements of the following listed organizations in effect at the date of the Notice-To-Proceed where the requirements do not conflict with these Specifications. In case of a conflict, the more stringent shall apply.

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
AWS	American Welding Society
ASTM	American Society for Testing and Materials
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineering Society
MEC	Massachusetts Electrical Code
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
UL	Underwriter's Laboratories, Inc.

1.6 ADJACENT CONTRACTS

A. The Contractor shall note that the work of other contracts and that required maintenance will be ongoing simultaneously within the limits of this Contract. The Contractor shall coordinate and cooperate with all other contractors and the MBTA, Operating Railroad and PAN AM Railroad workforces with regard to: schedule coordination, access to the site, maintenance, security, temporary facilities, cleaning of the site, and like matters requiring common effort. All parties will unite to protect all railroad property and operations.

1.7 SUBMITTALS

A. The Contractor shall provide submittals in accordance with the requirements of Section 01300 - Submittals and the other applicable technical sections of these Specifications. In general, the Contractor shall:

1. Submit an initial schedule identifying when and how each significant task and associated milestone will be met.

2. Submit individual installation plans, detailing work items, method and means of installation, manpower and durations.

3. Submit materials, equipment, and methods of work to be performed under this Contract as required within the respective section of specifications herein. All submittals shall be site specific and shall indicate the proposed location, application and purpose of material and equipment.

4. The Contractor shall provide all certificates of compliance for all equipment and personnel as required.

5. The Contractor shall be responsible to maintain a submittal check list (matrix) for the duration of this project. A typical submittal checklist is outlined in TA2.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide material and apparatus as specified in these Specifications and as shown on the Contract Drawings.

B. Provide new products and components that are free of manufacturing defects. Provide electrical components rated to operate at power, voltage, current and temperature levels, 20 percent greater than those to which components shall be subjected to when in service, unless otherwise specified herein.

C. All material furnished and installed by the Contractor shall be new and of the highest quality and shall be fully compatible with signal system presently in use on the Fitchburg Main Line

PART 3 – EXECUTION

3.1 GENERAL REQUIREMENTS

A. The Contract Drawings depicting equipment installation layouts are provided for bidding purpose and to assist the Contractor’s final detailed design specific to his equipment and the installation site.

B. Contact Drawings shall not be construed to apply in every instance or condition encountered during the construction. It is the Contractor’s responsibility to provide fully detailed installation plans during the construction of this Contract and obtain approval of the Engineer prior to installation.

1. The Contractor shall progress and update as required the development of the Contract Drawings into a final “AS-Built” package that is consistent with the system and equipment provided.

2. The Contractor shall provide detailing and material for the installation of the final cables, terminations, routing and plans.

3. The Contractor shall thoroughly review the Contract Drawings and resolve any question or discrepancies with the Engineer prior to initiating the installation of materials and equipment.

4. The Contractor shall be responsible for updates of cable drawings and the Contract Drawings with revision and modification due to field conditions encountered during installation. If the Contractor proposes alternating routing or a conflict occurs with the typical, then the Contractor shall submit his proposed plan for approval by the Engineer. Revision and modification shall be made on site and a copy of modified drawings submitted to the Engineer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for basic technical requirements but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the work will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16802

EQUIPMENT REMOVAL

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work described in this Section requires the Contractor to remove all materials and equipment retired under this Contract. It also specifies protection-in-place of signal equipment affected by both temporary and permanent modifications to the signal system, grade crossings and reconstruction of the Washington Street Bridge over the railroad.

B. The Engineer will determine the final disposition of retired material and equipment prior to scheduled removal. Material and equipment that cannot be identified as either salvage, or scrap, shall be stored by the Contractor, in a secured area, until such time that the final disposition is determined. The Contractor shall provide the approved documentation recording the delivery of the materials and acceptance by the Authority.

C. The Contractor shall keep detailed records, of all material and equipment to be retired. All material retired as a result of this Contract, whether salvaged or removed from the MBTA right-of-way by the Contractor shall be accounted for.

D. Removal, extraction or demolition of materials and equipment shall result in the complete elimination of all designated element of existing facilities from the site. Unwanted material and associated debris shall be disposed of in an approved manner with the Contractor responsible for all required permits.

E. All staged or temporary work shall be removed from the site and the site shall be restored to the original condition.

1.2 QUALITY ASSURANCE

A. Remove retired equipment as shown on the Contract Drawings and described herein, and remove debris from the site. Use such methods as required to complete the work within the limitations of governing regulations.

B. All the work specified herein shall be performed in close coordination with and under the supervision of the Authority personnel prior to and during the actual removal, salvage and disposal of any existing signal, communications and electrical system equipment.

1.3 SUBMITTALS

A. Prior to commencement of construction activity the Contractor shall submit for approval proposed material and methods for protection of existing equipment.

B. The Contractor shall submit a plan(s) of the method and means by which the existing facilities shall be removed or protected-in-place. The submittal shall include sufficient information to enable evaluation by the Engineer of the adequacy of the proposal to provide removal and/or protection. Approval of a typical plan shall

not relieve the Contractor from the requirement of providing additional or more specific submittals as the Engineer deems necessary to suit conditions. Submittals shall be provided no later than three weeks prior to the scheduled date of the removal.

C. Submit fully executed copies of all permits, if any.

D. Submit a standard form to be used for documenting removal, storage and disposal of existing materials due to the work of this Contract.

1.4 DELIVERY, STORAGE AND HANDLING

A. The Contractor shall store all material and equipment deemed to be salvage, in an approved secured area, until such time as it can be delivered to the MBTA or Operating RR.

B. The Contractor shall be responsible for any damage to materials and equipment sustained during removal, demolition, storage or delivery. Damaged material and/or equipment shall be repaired or replaced by the Contractor at no additional cost to the Contract.

PART 3 - EXECUTION

3.1 GENERAL

A. All demolition and disposal shall be performed in accordance with applicable codes, and all federal, State, and Local requirements.

B. Provide labor, material, equipment, and services necessary to perform any temporary or interim work required to facilitate the demolition of materials and equipment and the construction required under this Contract.

C. Prior to the beginning of demolition all existing signal facilities within construction area shall be surveyed by the Contractor and the Authority.

1. Prior to removal of any facilities, the Contractor shall inspect the existing equipment for any damage and shall report any existing damage to the Authority in writing.

2. Any facilities damaged at the time of Authority acceptance and not previously reported shall be replaced in-kind by the Contractor at no additional cost to the Authority.

D. Signal equipment that is the subject to reuse by the Authority as identified by the Engineer shall be labeled, and disconnected in a careful manner so as to avoid any damage.

1. Remove and place in a crate, box, or pallet and deliver to the Authority at a location designated by the Engineer.

2. The Contractor shall also unload and stack the salvaged material at the designated location. Notify the Engineer at least three days in advance when equipment to be salvaged is ready to be identified.

3. All material not designated by the Authority to be salvaged shall be removed and disposed of by the Contractor.

E. The Contractor shall prepare material salvage reports, in quadruplicate on the approved forms, listing item description, location, condition, and date delivered. Upon delivery to the Authority, an appropriate Authority representative will verify receipt by signature. The Contractor shall tender three copies to the Authority.

F. The process and the manner of carrying out the removal of the existing signal facilities shall not incur any damage to these facilities or other existing Authority facilities, nor shall it adversely affect the new signal equipment installed under this Contract. Any work required to repair and replace existing Authority facilities damaged by the Contractor during the removal work shall be carried out at no additional cost to the Authority without any delays to the Contract.

G. No equipment under this Contract, described as existing signal system facilities, shall be abandoned in-place unless specifically accepted herein or by Authority direction.

1. Retired aerial cables, including the messenger, and all associated cable straps, shall be removed and scrapped.

2. Poles to be removed shall be cut 6 inches below finished grade if unable to be pulled out and removed to an appropriate site.

3. Existing direct buried cables, that are to be retired, shall be abandoned in place, but ends cut back to 20 inches below finished grade.

H. Where removed facilities leave a mounting or securing remnant that results in a protrusion or void, the protrusion or void shall be rendered non-hazardous to the personnel or railroad operations in a manner approved by the Authority.

1. Existing foundations, that are to be retired, shall be demolished and excavated to a point 6 inches below finished grade, or shall be excavated and removed, as directed by the Engineer.

I. Wayside signal cases, relays and miscellaneous equipment mounted inside and outside the wayside signal cases or Signal Instrument House (SIH) designated for removal shall be removed, protected and delivered to the Authority. Every relay shall be individually packed, other internal equipment maybe identified by the Engineer as needed to be packaged and protected for transport to a facility.

J. Rail bonds, potheads, cable leads and rail connections shall be removed and disposed of, in an approved manner, off-site by the Contractor and remnants buried to a depth of 30 inches.

K. Wayside signal assemblies including ladders, brackets, signs and integral junction box cases designated to be removed shall be removed and delivered to the Authority.

3.2 EQUIPMENT REMOVAL

A. All non-salvaged signal material removed from the project shall be delivered to the approved disposal site as submitted in the Contractor's "Certificate of Dumping Facilities" in the Contract Proposal.

B. The Contractor shall remove and dispose of all equipment, including cable disconnected by this Contract and located in the duct system or conduit up to and including removing wires and cable following MBCR disconnect from termination points.

3.3 PROTECTION OF FACILITIES

A. The Contractor shall protect in place all equipment identified as temporary or permanent to avoid any damage during the execution of the work.

B. The Contractor shall protect the existing track structure from damage, and shall protect the existing ballast from contamination.

C. Any equipment damaged by Contractor shall be replaced in-kind with new, without time extension and at no additional cost and to the Authority.

3.4 CLEAN UP

A. The Contractor shall remove all protective materials from the signal equipment and dispose of that material off-site, as approved.

B. Any excavation shall be returned to final grade.

3.5 DEMOLITION/SALVAGE OF EXISTING SIGNAL EQUIPMENT AND SYSTEMS

A. Existing Signal Houses

1. All existing equipment contained in each enclosure shall be inventoried and identified by manufacturer and product description prior to removal.
2. All vital and non-vital relays relay bases, transformers, battery chargers, and other electric and electronic equipment shall be salvaged, and removed from the shelter.
3. Relays and similarly delicate equipment shall be packed in protective cartons and delivered to the MBTA or Operating RR. Each carton shall be fully identified.
4. Racks and terminal boards shall be retired and scrapped or salvaged as directed by the Engineer.
5. Batteries shall be salvaged or disposed of properly as directed by the Engineer

B. Wayside Cases

1. All existing equipment contained in each wayside case shall be inventoried and identified by manufacturer and product description prior to removal.
2. Track transformers and associated track circuit equipment and all other electric and electronic equipment shall be salvaged and removed prior to moving the case.
3. Relays, if any and similarly delicate equipment shall be packed in protective cartons and shipped to the MBTA or Operating RR. Each carton shall be fully identified.
4. The cases, including racks and terminal boards shall be retired and scrapped or salvaged as directed by the Engineer.

5. Batteries shall be salvaged or disposed of properly as directed by the Engineer.

C. All local cables to be retired shall be cut back to 20 inches below finished grade.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for equipment removal but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the removal will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16804

DRAWINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the production and furnishing of drawings and describes the general format of drawings, types of drawings, and the manner in which information shall be displayed for submittal drawings, working drawings and As-built drawings. The classes of drawings are as follows:

1. Submittal Drawings (Shop Drawings) – Drawings displaying systems, subsystems, products, arrangements and layouts, etc.

2. Working Drawings – Drawings that have been submitted and approved for use in the installation of the project

3. As-Built Drawings – Drawings which show the actual installation of the Contract as approved and accepted.

B. The accuracy and corrections of all drawings are the responsibility of the Contractor, and the approvals of those drawings shall be granted on format only.

C. The Contract Drawings show the work to be installed under this Contract. The Contractor shall be required to mark up the plans to show actual cable and conduit locations.

D. The Contractor shall provide copies to the Engineer in Autocad or Microstation electronic format.

E. The Contractor shall provide 11”x17” paper copies in the field at the nearest SIH. In addition, the Contractor’s attention is directed toward the fact that certain locations may require special layouts. In such cases, the Contractor shall submit the designs and /or arrangements which he proposes to use to the Engineer for approval.

1.2 QUALITY ASSURANCE

A. Check drawings for both form and content prior to submittal. Points to be checked shall include the following:

1. Conformance to the Specification

2. Logical grouping and arrangement of subject matter

3. Accuracy

4. Legibility

5. Neatness

6. Line Quality

7. Letting Quality

8. Reproduction Quality

9. Inclusion of Contract specified interfaces with related contracts

B. Approval of drawings shall be at the discretion of the Engineer. The Engineer will consider the same points enumerated above, with the basic criteria for obtaining approval being that drawings are easy to read, understand and use.

C. Drawing shall not be crowded or cluttered, but shall be arranged for easy reading for troubleshooting and maintaining.

D. Line Plans shall identify the starting point and show the effective distance of all express cabling from centerline of nearest main line track, survey station for all signals, interlocked switches, track cut sections, highway grade crossings, electric locks, signal instrument houses or terminal housings, junction boxes etc.

1.3 SUBMITTALS

A. When submitting drawings to the Engineer for initial approval of a product, subsystem or location, submit 10 copies of all drawings pertaining to the subject at one time. This logical grouping of drawings, sufficient to completely cover the subject concerned, shall be known as a “Submittal Package”. Submittals shall be made in accordance with Section 01300.

B. Submit samples of the final drawings within 90 days after receipt of a Notice-To-Proceed.

C. Submit sample in Microstation and or Autocad format of as-built cable drawing. An overwritten pdf of the line plan or track and cable plans may be acceptable.

D. Submit a legible copy of all as-built drawings to the Engineer for approval. These drawings shall be complete and detailed and shall include the following:

1. Cable Line Plans showing placement of cables from centerline of nearest main line track.

2. Track and Cable Plans showing placement of cables.

3. Site Plans and Conduit/Cable Layout (Scaled) showing method of spanning bridges, culverts or other obstacles, and as required by the Engineer.

4. Temporary Plans.

1.4 TYPES OF DRAWINGS

The types of drawings to be provided shall include, but are not limited to the following:

A. A Cover Sheet which shall bear the name of the submittal package and the name and location of the plan book in two inch high letters.

B. Index Sheet to include the arrangement order and description of the plans

C. Drawings which indicate point-to-point cable runs and identify cable make-up and conductor wire size shall be defined as Cable line Plans. These plans shall show the single line track configuration and identify each track, signal, and related items of signal apparatus. These drawings shall identify conduit, duct or raceway location and shall indicate the installed cables. Existing line plan can be used. Overwrite the line plan with the actual cable routing.

D. Drawings which indicate point-to-point cable runs and identify cable make-up and conductor wire size shall be defined as Track and Cable Plans. These plans shall show the double line track configuration and identify each track circuit, signal, and related items of signal apparatus. These drawings shall identify conduit, duct or raceway location and shall indicate the required sizes of all such conduit, duct work, and cables. Existing track and cable can be used. Overwrite the existing track and cable or routing plan to show actual conduit placement and cable routing.

E. Drawings, to scale showing the location of duct banks including manholes and hand holes and locations of the conduit ends installed for cable under bridges, over, bridges, culverts, rock cuts and other obstacles and as shown on the Contract Drawings shall be known as Site Plans and Conduit/Cable Layout (Scaled). These plans shall identify the actual method of attachment, (hanging), fastening, suspending or installation of conduit, duct or raceway location and shall indicate the required sizes of all such conduit, duct work, fastening materials and cables.

F. Drawings showing any temporary work required, but will not remain as part of the completed work shall be known as TEMPORARY PLANS and shall be entitled to define the purpose served.

PART 2 - PRODUCTS

2.1 MATERIAL

A. Final As-Built drawings shall be:

1. Electronic copy CAD and PDF and ten (10) hard copy of the as-built contract drawings

2. A paper copy of as-built drawing(s) shall be left in the field at the appropriate signal housing.

PART 3 - EXECUTION

3.1 PLAN BOOKS FOR INSTALLATION

A. The Contractor shall maintain a complete set of up-to-date as-built book of plans for each location of this Contract at the specific location. At no time shall a location be left without a complete set of up-to-date plans.

B. The Contractor shall maintain an additional; complete set of up-to-date book of plans for this Contract at his on-site headquarter and another at the Engineers project office.

C. The location shall be clearly marked on the final As-Built drawings.

D. During the progress of work, prints shall be made showing the latest revision of work completed and put in-service.

E. The Contractor shall provide the Engineer an electronic as built copy of the plans no later than 30 days after placing any portion of the work shown on the approved plans in-service.

F. When recording work in progress the Contractor shall use an “X” for removal and “O” for additions symbols. An orange pencil shall be used to show the conditions are acceptable, brown for verified tags, red for changes to remover and green for changes to be added.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for drawings but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the drawings will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16806

EXCAVATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the furnishing of all labor, material, and equipment required for safe excavation, trenching, backfilling, tamping and grading for cable, conduits, footings, concrete pads, troughs, signal houses and foundations for signal cases, junction cases, signals, and other facilities at various locations as indicated herein and on the Contract Drawings.

B. Rock excavation, if encountered, shall be included in this Section and is defined as the removal and disposal of materials in-place that cannot be loosened or broken down by ripping, or by the use of modern construction earth excavating equipment.

C. Materials which require special rock excavation equipment, or blasting for removal, such as boulders measuring one-half cubic yard or more, and all solid rock, masonry, and concrete pavements requiring hand power tools for fragmenting prior to removal shall also be included in this Section.

D. Sheeting, shoring, and de-watering of excavated areas and trenches shall be included as necessary for the work described herein.

E. Backfill materials shall consist of suitable on-site earth excavation; crushed stone, sand, and gravel borrow as specified herein.

F. The Contractor shall not excavate under or near track so as to adversely affect its integrity without prior approval of construction method and with the Engineers approval.

G. Comply fully with the requirements of the following Divisions 2 Standard Specification Sections: Section 02300 – Earthwork

1.2 QUALITY ASSURANCE

A. Backfill materials specified shall be approved by the Engineer prior to placement. The Contractor shall arrange for material analysis and all certifications as directed by the Engineer, at no additional cost to the Contract.

B. Any voids shall be backfilled again until stabilized.

C. Backfill in a manner to prevent washouts.

1.3 SUBMITTALS

A. A description of materials and methods of installation to be furnished under this Contract including, but not limited to, types of cable trough systems, conduits, hand holes, etc.

B. Certified compaction test reports for material required to be compacted, as specified in various Sections of these and the MBTA Standard Specifications. The percent compaction shall be in accordance with applicable Sections of these Specifications.

C. The type of protective covering to be used to prevent contamination of existing ballast during excavation.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Backfill materials delivered to the site and excavated materials suitable for backfill shall be stored in areas designated by the Engineer in neat piles which will not interfere with railroad system operating traffic movements or work being performed by others. Surplus excavated materials not required for backfill shall be removed from the site for disposal as soon as possible.

1.5 JOB CONDITIONS

A. Sheeting and shoring of trenches shall be in conformance with applicable local and other governmental codes and regulations.

B. Transportation of backfill materials and dust control on or near the work shall be in compliance with applicable environmental codes and regulations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General requirements pertaining to trenching and backfill materials are as follows:

1. On-site materials obtained from trench and other excavation, to be used as ordinary backfill under this Contract shall have physical characteristics of soils designated as group A-1, A-2-4 or A-3 under AASHTO M-145.

2. Crushed stone base for foundations and replacement of excavated ballast shall be AREA size No. 5 having the following gradation:

Size of Opening	Percent Passing by Weight
1-1/2 inches	100
1 inch	90 - 100
3/4 inch	40 - 75
1/2 inch	15 - 35
3/8 inch	0 - 15
No. 4	0 - 5

3. Sand for cable bedding shall consist of clean, inert, hard, durable grains of quartz or other hard, durable rock, free from loam or clay, surface coatings, and deleterious materials. The allowable amount of material passing a No. 200 sieve as determined by AASHTO T11 shall not exceed ten percent by weight.

4. Gravel backfill shall consist of inert material that is hard, durable stone and coarse sand, free from loam or clay, surface coatings, and deleterious materials.

   a. Gradation requirements for gravel shall be determined by AASHTO T-27 and shall conform to the following:

Sieve	Percent Passing
1/2 inch	50 - 85
No. 4	40 - 75
No. 50	8-28
No. 200	0-8

   b. The maximum size of stone shall not exceed three inches.

5. The Contractor shall furnish trench marker tape for signal cable, bright yellow, six inches wide and continuously coded in black lettering with the following legend:

CAUTION	CAUTION	CAUTION
BURIED	SIGNAL	CABLE

Tape for electrical or communication trenches shall be similar except coded within the legend corresponding to the type of cable installed with the trench.

PART 3 - EXECUTION

3.1 CONSTRUCTION

A. Excavation work shall be conducted as follows:

1. Over-excavation shall be kept to a minimum and any over-excavation below the required grades shall be replaced with backfill material meeting the specified requirements, at no additional cost to the Contract.

2. The Contractor shall locate, dig, and backfill the trench with minimum disturbance to drainage, electrical, or other existing systems. The Contractor shall re-establish and/or repair any portion of the drainage system that may have been disturbed.

The Contractor shall immediately notify the Engineer of any breaks or disturbances of the existing cables. Repairs to existing systems disturbed during excavation shall be made at no additional cost to the Contract.

3. Wherever excavation is required under or adjacent to tracks that are in service, the Contractor shall provide such sheeting and shoring as is necessary to prevent damage to the track structure and shall complete his excavation and backfill operations within the same workday.

4. A protective covering shall be provided over track ballast to prevent contamination during excavation and backfill operations. Where it is not possible to provide a protective covering, the Contractor shall remove the contaminated ballast and replace with crushed stone that shall be compacted as described herein.

5. Soft or unsuitable material existing below the required subgrade shall be removed and replaced with gravel, crushed stone, or other suitable material, as directed by the Engineer, and thoroughly compacted. Rock or boulders shall be removed below the subgrade to a minimum depth of one foot below the bottom of foundations.

6. Excavation required for placement of cable trough and related systems shall be in accordance with manufacturer's recommended installation practices and with methods shown in the approved Contractor's submittal for cable trough installation.

7. Subgrades for conduit or cable trenches paralleling the tracks shall not be less than thirty inches (minimum) below finished earth or ballast unless otherwise approved by the Engineer. When passing under tracks, trenches for conduit or cable shall be not less than forty-eight inches below the top of rail. Power cables, where run separately, shall be a minimum of one foot below the signal cable(s).

8. Where cross pipes, drains, cables, or other unforeseen obstacles are encountered, or where clearances are not in conformance with national and local codes, the proposed line and grade of the cable trench or foundation may be altered after securing prior approval of the Engineer.

B. Sheeting and Shoring

1. When conduit and foundations are being installed in a trench or hole, the Contractor shall furnish, install, and maintain such sheeting and shoring as may be required to support the sides of such excavations and adjacent structures. Should the Contractor be permitted to slope the sides of such excavations so that sheeting, shoring, or bracing is not necessary to prevent cave-ins or slides along the excavation, such additional excavation and backfilling shall be done at no additional cost to the Contract.

2. Unless otherwise approved by the Engineer, all excavation supports shall be removed upon completion of, or during backfill operations.

C. Dewatering

1. The Contractor shall provide and maintain, at all times during construction, ample means and equipment to promptly remove and dispose of all water from every source entering the excavations or other parts of the work, to ensure dry excavations and the preservation of the lines and grades of bottoms of excavations.

D. Backfill

1. After excavation to subgrade has been completed, the specified fill shall be placed and compacted as described herein.

2. Backfill operations shall not commence without the approval of the excavation by the Engineer.

E. Crushed Stone

1. At all locations where pre-cast or cast-in-place concrete foundations or outdoor cable troughs are installed, a crushed stone base shall be placed and compacted on the accepted subgrade to a total depth of not less than four inches after compaction. Crushed stone shall be placed and compacted at locations where track ballast has been removed and/or fouled by the Contractor's operations and as directed by the Engineer.

F. Sand

1. Prior to the installation of underground cables a bed of sand compacted to a depth of not less than four inches shall be placed on the accepted subgrade. Following the installation of the cables, sand backfill shall be placed and compacted with hand tools around and over the cables in four-inch to six-inch layers, to a uniform depth not less than six inches over the cables without damage to the cables.

G. Gravel

1. In the event that the on-site excavated soil materials, or any part thereof, do not conform to the solid characteristics specified in this Section, gravel material shall be placed and compacted in uniform layers not exceeding eight inches for backfilling trenches beyond the specified limits for crushed stone and sand backfill.

H. On-site Material

1. All suitable soil material, excavated by the Contractor for cable trenches and foundations conforming to the material specification of this Section shall be used for backfilling trenches and foundations beyond the specified limits for crushed stone backfill. Material shall be placed and compacted in uniform layers not exceeding eight inches.

I. Compaction

1. Sand, gravel and on-site backfill shall be compacted to not less than 95% of the maximum dry density of the respective materials, as determined by AASHTO Test Designation T-99. Crushed

stone shall be compacted with vibratory compactors to distribute the particle sizes and to provide a compact base with free-draining characteristics.

2. All mechanical equipment for compaction of backfill shall be subject to the approval of the Engineer.

J. Trench Marker Tape

1. When installing backfill over direct burial cable or conduit runs, the Contractor shall also install the polyethylene color-coded tape approximately 12 inches below the finished grade for the full length of each run.

2. Two weeks after backfilling, the Contractor shall perform an inspection to observe settlement; any voids shall be backfilled and checked again two weeks later until the areas of excavation have stabilized.

K. Clean-up and Disposal

1. Immediately upon completion of the work described herein, or any segments thereof, and as directed by the Engineer, the Contractor shall remove and dispose of all debris and surplus excavated material away from the site.

L. Safety

1. All excavation areas shall be covered/protected to eliminate any possibility of a tripping or falling hazard. At the end of each work shift any ground openings shall be safely covered and an approved barrier, snow fence as a minimum, shall be in place at all times to prevent inadvertent passage through the excavation area.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for excavation associated with the grade crossing reconstruction work, but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the excavation work will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16807

CONCRETE AND OTHER FOUNDATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies furnishing and installing precast concrete foundations. Foundations to be furnished and installed shall be complete with galvanized anchor bolts, washers, nuts and associated hardware.

B. Precast concrete foundations shall be furnished and installed for gate foundations as specified herein and as shown on the Contract Drawings

C. All foundations shall include all fastening hardware and associated material

D. All general construction effort which includes items such as excavation for foundations, site clearing and restoration shall be the responsibility of the Contractor

1.2 QUALITY ASSURANCE

A. Concrete for precast foundations shall be in accordance with specifications of the American Railway Engineering Association entitled "Specifications for Concrete Structures, Chapter 8" with a compressive strength of not less than 5,000 psi.

B. A permanent record shall be kept by the precast fabricator of the date and conditions of casting of each unit.

1.3 SUBMITTALS

A. The Contractor shall submit the following for approval:

1. Catalog cuts and descriptive literature for all material as specified herein and as shown on the Contract Drawings.

2. Drawings of the cast-in-place and precast foundations proposed to be furnished and installed. These drawings shall include the following:

    a. Physical Dimensions

    b. Type of Formwork

    c. Reinforcing

    d. Bolt spacing, size and detail of galvanized bolts, nuts and washers

    e. Depth of foundation from top of finished grade

    f. Cable entry openings

    g. Proposed location

B. Upon the Engineer's request, submit the following for approval:

1. Drawings of the precast foundations proposed to be furnished and installed. These drawings shall include the following:

    a. Physical Dimensions

    b. Reinforcing

    c. Bolt spacing, size and detail of galvanized bolts, nuts and washers

    d. Depth of foundation from top of finished grade

    e. Cable entry opening

    f. Certification of Compliance

2. Two copies of the fabricator's records showing the date and conditions relating to the manufacture of each precast unit, which shall include type of fabricator's building or enclosure, form material used, curing procedures, (steam or water), temperature ranges, air entrainment content, water-cement ratio, method of finishing the units, and all other pertinent information.

3. Four certified copies of the tests conducted by the "Accredited Authoritative Testing Laboratory" for approval and acceptance of the precast units.

1.4 DELIVERY, STORAGE AND HANDLING

A. Materials shall be protected from damage throughout delivery, storage and handling. Comply fully with the requirements of Section 16801 Basic Technical Requirement.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Precast concrete foundations and piers shall be made of concrete with a compressive strength of not less than 5000 psi. and be in accordance with the applicable AREMA Signal Manual for the type of precast foundation required.

B. The pre-cast concrete foundations shall be specifically design for the support of the signal equipment it is supporting

C. Precast concrete foundations shall be steel reinforced. Reinforcing steel shall be placed not less than one inch from any outside surface.

D. Finish and Curing of Precast Foundations. Proper control of the water-cement ratio, high frequency vibration and controlled curing shall be used. An air entraining agent shall be used to increase the resistance to weathering. All outside surfaces shall present a flat smooth and finished appearance.

2.2 BOLTS, NUTS AND HARDWARE

A. Bolts, nuts and washers shall be galvanized. Nuts and threads shall be in accordance with AREMA Specifications for Bolts, Nuts and Threads.

B. Plain washers shall be in accordance with AREMA Specifications for Plain and Spring Lock Washers. Steel shall be in accordance with AREMA Specifications for Various Types of Steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Prior to placing precast concrete foundations, he excavation(s) and installation of crushed stone base shall be placed and compacted as specified in Section 16806.

B. Foundations and piers shall be buried to a minimum depth of 42 inches below top of finished grade, unless otherwise approved by the Engineer. Top of final grade to top of foundation shall be as shown on the Contract Drawings.

C. When placing foundations or pads, exercise care to ensure that anchor bolts are not bent or threads damaged. All anchor bolt threads, washers and nuts shall be protected by applying friction tape, or other approved method satisfactory to the Engineer, until such time as the unit to be supported is installed. Anchor bolts requiring leveling nuts shall be of sufficient length.

D. Foundation(s) and pad(s) shall be installed level and plumb.

E. If the surfaces of all foundations exposed to view do not present a uniformly clean surface of even texture and appearance, the surface shall be treated and rubbed to obtain a satisfactory finish, subject to approval by the Engineer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for concrete and other foundations but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the concrete or other foundation work will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16808

EXTERNAL SIGNAL CABLE

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies requirements for furnishing, installing and testing of all wiring and a new external signal cable system.

B. The Contractor shall furnish and install new signal cables, conduits and raceways required for the complete signal cable system. All cables shall be installed in conduit or direct buried as shown in the Contract Drawings.

C. Material and workmanship shall be of the highest quality to ensure durability for a minimum life expectancy of forty years. The cables shall be suitable for use in the environment to be encountered and shall be certified for continuous operation at 90 degrees C in wet or dry locations with no conductor failing in continuity or with loss of insulation to cross or ground less than fifty meg-ohms.

D. Express cables are defined as those cables that run between locations. Such as between crossings, automatic signals and interlocking's etc.

E. Local distribution cables are defined as those cables that run from SIH's and cases to equipment. Such as SIH to signal, track circuit and main SIH to east SIH etc.

F. Wire and cable to be furnished under this Contract shall meet the requirements of the MBTA's wire and cable specifications as stated herein and as listed in Technical Appendices, TA-1, of these Specifications.

G. The Contractor shall assure wire and cables are of adequate size and quantity for the system prior to installation.

1.2 QUALITY ASSURANCE

A. Rejected Wire and Cable – Wire and Cable that does not meet the requirements of this Specification shall be rejected. Wire and cable which shows defects or non-compliance with the Specification after delivery at destination may be rejected and the Contractor shall, on request, advise disposition of the wire and cable in question and pay all related transportation charges for the rejected and replacement material.

B. Approval of Signal Wire and Cable

1. All wire and cable manufacturers supplying cable for this Contract must be approved by the Authority. The Contractor shall provide all of the data required for the Engineer's evaluation and shall arrange for wire and cable samples, demonstrations and test, if requested.

2. Approval shall be based on the following criteria:

a. Past performance and experience: The wire and cable manufacturer(s) must demonstrate previous successful experience in supplying wire and cable to the railroad or transit industry for use as vital signal control, communication cable and electrical. A list of such installations shall be provided for each cable manufacturer under consideration.

b. Quality assurance program: The manufacture of wire and cables in accordance with the requirements of this Specification shall be accomplished in compliance with a quality assurance program that meets the intent of the ASQC Standard CI-1968; General Requirements for a Quality Program. Such compliance shall promote a thoroughly tested wire and cable that will render long service life to the user. Prime concern must be focused on the necessary formal assurance requirements to insure that wire and cable failure cannot be attributed to actions or lack of actions by the manufacturer.

c. Technical data: The Contractor shall provide full technical data demonstrating compliance with the requirements of this Specification for each specified wire and cable.

d. Demonstration tests: The Contractor shall make arrangements with the prospective cable manufacturer(s) to perform demonstration tests as required by the Engineer.

e. Sample specimens. The Contractor shall, if requested by the Authority, furnish within twenty (20) days after close of bid date, sample specimens in four-foot lengths for each type of wire and cable specified herein. Sample specimens shall remain the property of the MBTA (Authority).

f. The manufacturer shall certify that he shall comply with the following warranty clauses:

1) The manufacturer warrants that design, material and shall be of the highest quality and consistent with the established and generally accepted industry standards for wire and aerial and underground cable for vital railroad signal, communication, and power circuits; and that each such item and every part and component thereof shall comply with this Specification.

2) The manufacturer agrees that this warranty shall commence with the acceptance of each item of wire and cable, whether the defect be patent or latent, and shall apply for a period of two years after initial satisfactory operation or four years after acceptance, whichever is shorter.

3) The warranty covering any length of wire and cable replaced by the manufacturer under the above conditions shall be reinstated for a period of two years effective the date of replacement is affected. If failure is found to be of major significance and affects other wire and cable, the reinstatement of the warranty shall then be extended to cover the item so affected as well, and shall

start as of the date of such replacement. The warranty reinstatement provided for in this subparagraph (3) shall apply only to the first replacement or repair of any such item and, in the case of failure of major significance, to the first extension of the said warranty to said affected items.

4) The foregoing warranties are exclusive and in lieu of all other warranties, written, oral, implied or statutory (except as to title and freedom from lien). In no event shall the Manufacturer be liable by reason of breach of warranty for special or consequential damages.

5) Wire and cable furnished shall be traceable to the test data on file for each step in its manufacturing process.

3. Cable Inspections

a. Inspection:

1) The Authority, or its authorized representative, shall have the right to make inspections and tests to determine if the wire and cable meets the requirements of this Specification. The inspector for the Authority shall have the right to reject wire and cable that is found defective.

2) The Authority shall be given ten days advance notice of final wire and cable testing, so that the Authority may witness the tests, if it so elects.

3) Physical tests shall be made on samples selected at random at the place of production. Each test sample shall be taken from the accessible end of different reels. Each reel selected and the corresponding sample shall be identified. The number and lengths of samples shall be as specified under the individual tests. All applicable tests for the cable materials and cable construction specified shall be performed.

4) The manufacturer shall provide, at the point of production, apparatus and labor for making any or all of the following tests under the supervision of the Authority's inspector; to include:

- Conductor size and physical characteristics,
- Insulation HV and IR tests,
- Physical dimension tests,
- Special tests on materials in coverings,
- Final HV, IR, and conductor resistance tests on shipping reels.

5) Certified electrical and physical test reports shall be furnished for the finished multiple conductor cables no later than the time of shipment. Each test document

shall, in addition to the test results, indicate the date the tests were performed and the signature of the manufacturer's authorized representative.

6) The Authority reserves the right to conduct itself, or by its duly authorized representative, those tests it so elects to further satisfy itself that the cable is manufactured in accordance with the requirements of this Specification.

C. Signal Wire and Cable Termination – Quality Assurance Program

1. The Contractor shall develop a Quality Assurance program to assure that the proper procedures are followed to prepare and terminate signal cables on this contract. All work shall be performed using the highest quality of workmanship possible in a railroad signal, communications and electrical systems environment. This procedure covers supervision, training and implementation of that program.

2. An “assembly line” approach shall be used to strip the outer jackets; pothead the cables; affix eyelets to wire ends; terminate the conductors and perform megger tests. The Contractor shall inspect and maintain documentation on the various segments of the work. Under no circumstances shall the cables be unraveled or connected prior to visually inspecting for cuts, nicks or abrasions to conductors. The Contractor shall submit, for approval, Cable Termination Report Forms that shall be used to report the work and document/record inspections. These forms shall be submitted within five (5) days of an inspection. Every cable shall be inspected both prior to and after connection; the MBTA shall be notified 48 hours prior to each inspection, and reserves the right to witness the inspection.

3. All wiremen shall be pre-qualified in the use of the approved tools to perform the various functions to which they are assigned. Wiremen shall be trained on the use of proper tools. Wiremen engaged in tagging and termination shall also receive a short training on how to read cable wiring diagrams. The MBTA shall be notified 48 hours prior to each training session and reserves the right to witness and inspect the samples of work.

4. The requirements for pre-qualification are:

a. Wiremen engaged in stripping the outer jackets shall demonstrate their ability to properly remove the outer jackets using T-CA Magic Cable Strippers as manufactured by DLW Industries without damaging the inner conductors.

b. Wiremen stripping wire ends shall demonstrate their ability by using Ideal Stripmaster Wire Strippers 45-092 (for #14-#16-#10 AWG wire) and Ideal Cable Strippers (for #6 AWG wire) to properly remove the required amount of insulation without nicking the copper conductor.

c. Wiremen installing wire eyelets shall demonstrate their ability to properly install the eyelets by using new factory calibrated AMP crimping tools.

5. All cable and wire strippers shall be purchased new and shall of be the highest quality available on the market. Ten percent (10%) spare tools shall be available in case of damage to the tools in daily service. These tools shall be factory calibrated and shall be checked periodically in accordance with manufacturer's recommendations for wear or damage.

6. Tools for crimping on the eyes shall be new and factory calibrated at least every six (6) months. Calibration stickers shall be required on each tool.

7. To ensure that the proper tools are used, kits will be set-up and identified by kit number. All tools in each kit must also be numbered. Each wireman shall be assigned a number kit. The kit number and employee's name shall be recorded on a Cable Termination Report and submitted to the Engineer. The Contractor shall inspect theses kits daily, prior to the start of cable termination work, and shall immediately remove the kit from service if a discrepancy is found.

8. The Contractor shall not proceed with any wiring work if there is a noticeable problem with the tools or cable.

9. Any tools referenced above may be substituted with approved equals upon receiving written approval from the Engineer.

10. The conductor terminations shall be made by experienced personnel and be in conformance with the cable manufacturer's recommendations. Submit for approval the cable manufacturer's termination recommendations.

11. Splices in signal cables are not allowed.

12. The Engineer has the right to inspect any tools, materials or work, in conjunction with or independently of the Contractor. The Engineer has the right to stop work should any deficiencies be found and to only allow work to continue once the deficiencies have been resolved to his sole satisfaction.

1.3 SUBMITTALS

In accordance with the requirements of Section 01300 – Submittals, the Contractor shall submit the following for approval:

A. Signal Wire and Cable:

1. List of each cable manufacturer's railway signal installations;

2. Each cable manufacturer's Quality Assurance Program, including the manufacturer's testing procedure;

3. Manufacturer's technical information describing the cable and its electrical and mechanical characteristics including a cross-section drawing to include cable shape, construction, number of conductors, size, insulation thickness and type, jacket thickness and type, approximate weight per foot and outside diameter for each type of cable the Contractor proposes to use.

4. The Contractor shall furnish sample specimen of a four-foot length, if requested, for each proposed cable type. The samples shall remain the property of the Authority;

5. Certified factory cable test reports which shall include:

    a. Report Number,

    b. Date and location of test,

    c. Description of test, including the testing conditions,

    d. Complete cable or wire description,

    e. Lot, batch, and reel identification number,

    f. Quantitative test results including a completed, signed and notarized standard wire and cable test report sheet,

    g. Summary of the test results,

    h. Information on the components of the cable tested to include batch numbers and physical and electrical properties.

6. The Contractor shall submit two certified copies of the following for approval:

    a. Cable test reports for all demonstration tests required by the Engineer,

    b. Cable test and inspection reports for tests and inspections required and described by these Specifications,

    c. Test reports of cable tests conducted in the field in accordance with approved testing procedures,

    d. Certification that each cable supplied complies with the requirements of these Specifications.

7. The Contractor shall submit two copies of complete, signed and notarized standard Wire and Cable Test Report Sheet as part of each cable test report.

8. The Contractor shall furnish to the Authority ten copies of the cable manufacturer's instructions and procedures together with one sample end seal specimen for pot heading of each type all cable to be furnished and installed under this Contract.

9. Cable jacket removal and termination procedures;

10. Sample sheet showing format for Cable Termination Report Forms;

11. Cable Termination Report Forms when work is completed;

12. Cable pot heading method and product manufacturer;

13. Submit ten copies of detailed installation plans, showing all hardware to be used, methods of attachment, cable routing through conduits, troughs and pull boxes, etc. and including fill percentages, for approval prior to construction/installation, including but not limited to:

    a. Detailed cable routing plans.

    b. Pulling plans, including pulling tension calculations and Contractor's proposal for monitoring pulling tension during wire and cable installation.

    c. Cable bending radius plans demonstrating minimum bending radius compliance during installation and after installation is complete.

14. Submit for approval messenger attachment, size, usage, sag and tensions and cable pulling calculations for each individual cable run. The maximum pulling tensions shall be recorded for each cable pull and submitted to the Engineer.

15. Provide a final as built copy in the case adjacent to the cable run. Submit to Engineer Final as-builts in electronic format.

16. Splicing of signal wire and cable will not be allowed.

B. Indication and Control Cable (I & C)

1. The Contractor shall provide seven copies of complete technical data, including catalog cuts for all cables to be supplied.

2. Results of tests on 100% completed cable including:

    a. Shield continuity,

    b. Dielectric strength between conductors and shield,

    c. Conductor continuity, electrical strength between conductors,

    d. Average mutual capacitance,

    e. Demonstration test results, as required,

    f. Certificates of compliance that the cable meets the requirements of these Specifications and REA references.

3. Catalog cuts for indication and control cables,

4. Splicing of I&C cables will not be allowed.

C. C. Communications Cable and Fiber Optic

1. Submittal requirements same as above for I&C cable.

2. Splicing of communications cabling will not be allowed.

D. Power Distribution Cable

1. Submittal requirements same as above for signal cable & wire.

E. Splicing of power cabling will not be allowed. 1.04 DELIVERY, STORAGE AND HANDLING A. Ship all wire and cable on reels, adequately protected by heavy wrapping or wood lagging from damage during shipment. The Contractor shall be responsible for any defect in wire or cable occurring in transit. External protective wrapping shall be secured to reels to protect cable during shipment.

F. Provide reels designed and constructed to withstand handling and so both ends of wire or cable are secured and accessible but protected from injury. If the inner end of the wire or cable projects through the flange of the reel, protect the inner end with a suitable cover of metal with rounded ends and sides and securely fastened in place to protect the wire or cable end. Secure both ends of wire or cable on the reel in place, to prevent their becoming loose in transit or during handling of the reel.

G. Provide reel drums with a radius larger than the minimum bending radius of the cable to prevent damage to wire or cable during reeling. The arbor hole shall admit a spindle 2- 1/2 (two and one-half) inches in diameter without binding. Ship wire and cable in nonreturnable reels.

H. After acceptance of factory tests, seal wire or cable against the entrance of moisture. Protect both ends of each length of wire or cable with wrappings of rubber tape and plastic tape, or an effective boot taped or sealed into place, or by other suitable means approved by the Authority. The use of friction tape, other than as an external mechanical protection over an adequate rubber and/or plastic tape, will not be accepted. The wire or cable end protection shall be adequate to protect wire or cable in shipment and for prolonged external storage.

I. Wind each layer of wire or cable closely and tightly on the reel in a uniform manner.

J. Paint an arrow on one head of each reel pointing to the opposite direction from the outer end of the wire or cable, with the words "Roll This Way", using letters not less than 3/4- inch in height and arrow not less than six inches in length and 1/2-inch in width.

K. Requirements for shipping, storage, and handling shall also be in accordance with AREMA C&S Manual, Parts 10.4.1 and 10.3.16 as well as other provisions established throughout these Specifications.

PART 2 - PRODUCTS

2.1 SIGNAL WIRE AND CABLE

A. Provide the wire and cable under this Contract for signal, communication and electrical applications to meet the requirements of the designed MBTA wire and cable specifications contained within MBTA Technical Appendix, TA-1 of these Specifications, and hereby made part of these Specifications.

B. All wire and cable supplied shall be as manufactured by Rockbestos Surprenant Cable Corporation, Okonite Company, BIW, or approved equal. The standard cable make-ups shall be as follows:

1. Generally 12, 19, 27 and 37 Conductor No. 14 AWG solid, installed between the SIH (Express) and wayside (Local) junction boxes. These cables are to be used as line circuits between points, to junction boxes and snowmelter control/indication cable to heater cases and as directed by contract drawings and documents..

2. Color Light Signals: 7 conductor #9 AWG solid installed between SIH or case to signal unit. Contract documents and drawings will note any locations where the need for upsizing wire gauge due to distance from source.

3. Track Circuits: 2 conductor #6 AWG solid twisted from SIH or case to track.

4. Highway-rail grade crossing signal with gate: Two separate cables. 7 conductor cable consisting of (7) #6 AWG solid and a 10 conductor cable consisting of (10) #9 AWG solid.

5. Highway-rail grade crossing signal without gate (Flasher): 7 conductor #9 AWG solid.

6. Signal Power Secondary

   a. 120/240 Volt, 200A supply for wayside and crossings and 480/277 Volt, 400A supply for interlocking's require: 3 single conductor #1/0 and 1 single conductor #2 AWG.

C. Furnish 1000 Volt class wire and cable, XHHW-2 INSULATION, for all 120/240, 120/208 Volt and 480/277 Volt circuits supplying power to signal facilities.

2.2 CABLE MAKE-UP

A. General

1. If any cables are required above and beyond those shown on the Contract Drawings the Contractor shall determine size of conductors and cable make-up to meet design requirements. Increases conductor sizes, as necessary, to be in accordance with the National Electrical Code requirements.

2. If the Contractor's proposed signal system equipment requires use of shielded cable, the price of such shielded cables shall be included in the bid. Provide shielded cables meeting all requirements of these Specifications.

3. The Contractor will be required to supply all cables, wires and ancillary materials and equipment for this project in sufficient quantities and qualities as prescribed by the MBTA Cable Specification Technical Appendices TA-1 and the recommendations of AREMA Section 10 Wire and Cable, inclusive.

B. Spare Requirements

1. The Contractor shall provide spare conductors in all multi-conductor cables. Multi-conductor cables originating at SIH and continuing to wayside junction boxes/cases shall contain a minimum of 20 percent spare conductors. Local distribution cables shall contain a minimum of ten percent spare

conductors or minimum of one spare conductor, except that a two conductor local cable will not require a spare conductor.

2. Where more than one cable is used between the same locations, the quantity of spare wires/pairs shall not be less than 20 percent of the total number of working wires/pairs, but in no case shall the total quantity of spare wires/pairs be less than the quantity of spare wires/pairs required in the largest cable in the group.

2.3 NOT USED

2.4 SEALING OF CABLE ENTRANCES

A. Any voids remaining, where cables enter housings, cases, junction boxes, signals, switch machines, or any other apparatus, shall be made water-tight with cold sealing compound in accordance with AREMA C&S Manual, Part 15.2.15.

B. After cable installation, seal all conduit ends, whether above or below ground with "Duxseal" as manufactured by OZ Gedney, "Flame-Safe" as manufactured by T&B, or any approved expanding foam filler.

C. All cable entrance openings in equipment enclosures and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Dry sand shall be used to fill openings, chutes, risers. (Digging below the riser will release the sand) Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe, or duct bank. All spare conduits shall be sealed or plugged in an approved manner. Spare conduits will have a pull string installed and taped off on either ends for future use!

2.5 WIRE – INTERNAL

A. Internal wire and cable shall be as specified in 16855.

2.6 TAGS

A. Tags for identification of individual wires and cable conductors and field-installed wire shall be the sleeve type as manufactured by RAYCHEM RPS-1K-8-4/2.0-9, or approved equal.

B. Tags for cables shall be the PANDUIT flag type, or approved equal.

C. Back-wired terminal boards in SIHs, and cases shall be provided with factory-printed strip tags with wire nomenclature adjacent to the wire entrance hole on the terminal board. Front-wired terminal boards in junction boxes shall have sleeve tags affixed to each individual conductor. Brass cable tags 2" in diameter shall be supplied to identify individual cables entering each house, case or junction box in accordance with the Contractor's installation drawings, as approved by the Engineer. All wires and cables shall be equipped at both ends with an approved tag.

D. All strip and sleeve tags shall be machine printed.

F. Three line sleeve type tags shall state the cable identification with “TO”, “NOMENCLATURE”, and “FROM” destinations.

G. Spare conductors shall also be identified as “Spare” in the “NOMENCLATURE” line of the tag.

H. Submit catalog cuts or samples of each type of cable, wire, and equipment identification tags to be installed.

I. Additional information regarding tagging is presented in Section 16897 - Miscellaneous Components and Products.

PART 3 - EXECUTION

3.1 WIRE AND CABLE INSTALLATION

A. General

1. The installation of wire and cable shall conform to Part 10.4.1 of the AREMA C&S Manual, except as modified herein.

2. The Contractor shall give the Engineer 24 hours’ notice prior to installing cables.

3. Cables shall not be bent to a radius less than 10 times the diameter of the cable during installation or as finally installed. Express cables and fiber optic shall be installed with a minimum radius of curvature of 25 feet.

4. All signal cable runs shall be continuous without splices between cable terminating locations. Every effort shall be made for continuous runs without breaks. Junction boxes are required where a continuous length exceeds the reel length obtainable and all terminated cable wires within junction boxes will be identified by tags as previously explained within the section and requires the Engineers approval.

5. Inspect wire and cable carefully prior to installation to be certain that the wire and cable is free from defects. It is suggested that the Contractor megger test the cable on the reels prior to installation for continuity and crossmeggering. This does not relieve the Contractor from final cable testing and results when both cable ends are dressed within their final terminating points.

6. Any instance of damage to existing, operating wire and cable facilities which occurs during construction, or is discovered subsequent to construction activities, shall be immediately reported to the Operating Railroad or MBTA. Operating RR forces will promptly make necessary repairs with all necessary assistance by the Contractor, with all related costs, MBTA/Operating RR and other, to be paid by the Contractor within 60 days. In the case of damage to any new wire and cable facilities installed under this Contract, the Contractor shall be solely responsible to provide repair or replacement of such wire and cable, depending on the nature of repair and correction of any damage shall be as prescribed by written instruction from the MBTA/Operating RR. And Project Engineer.

7. When pulling cable, an approved wire cable grip, extending not less than 18 inches back from the end of the cable, shall be used. Clutch on the pulling device shall be set to slip at 50 percent of the cable manufacturer's allowable maximum. The equipment used for pulling cable shall be equipped with a dynamometer, which shall continuously indicate the pulling force in pounds. The maximum pulling tensions shall be recorded for each cable pull and submitted to the Engineer.

8. A suitable lubricating medium, non-injurious to the cable insulation, shall be used when pulling cables into conduit, pipe, or duct bank.

9. Cables shall not cross one another when they are placed in a trench, or pulled into a conduit or pipe and care shall be taken not to have the conductors pulled tight or kinked. All cables to be installed in the same conduit shall be pulled and installed simultaneously.

10. The track bed and ballast shall be protected from contamination during cable installation, and shall be restored to the existing condition after cable installation. Plastic tarps and plywood shall be used to prevent ballast contamination.

11. Where buried cables enter a concrete foundation, junction box signal house, or case, five feet of slack for each cable shall be left in the trench below the foundation or pedestal. Do not coil the cable slack used with electronic equipment. The FRE conduit end shall be sealed to prevent water penetration and the cable shall be encased in a minimum of three (3) inches of sand. Cable marker tape shall also be installed over top of the cable coil at a depth of one (1) foot below the finished grade.

12. Where signal, communications or track cables are installed in the same trench as or are required to intersect low voltage power cables, these cables shall be installed such that the distance between such cable and the low voltage power cable shall not be less than 12 inches, while maintaining the cover depth of not less than 30 inches for the cable. The 12 inches between any intersecting direct burial cables of different voltages as specified herein shall be filled with sand to a distance of two feet from each cable from the point of intersection.

13. Cable carrying 480V or more shall not be installed in the same trench, conduit, trough, messenger or other raceway as signal cable without desired spacing or Engineers approval.

14. The Contractor shall provide appropriate special protection for wire and cable in areas where the cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment. The Contractor shall be responsible for the replacement, at no additional cost to the Authority, or any cable that is subsequently damaged as a result of a failure to provide such special protection.

15. Cables shall be protected by conduit across bridges, culverts, thru rock cuts, under tracks, where minimum cover depths cannot be maintained, where minimum side clearances cannot be maintained and as shown on the Contract Drawings.

16. Where cable leaves the ground at other than buildings or in foundations, it must be protected by a bootleg or other covering extending above the ground line. Top of such protective coverings shall be filled with a sealing compound.

17. Restoration of backfill and ballast shall be in accordance with the construction methods outlined in Section 16806.

18. Cable marker tape shall be installed over top of all underground cables at a depth of one (1) foot below finished grade for the length of the entire run.

19. Where cable transfers from trays, troughs, or messenger into a conduit, the ends of the conduit shall be fitted with bell ends to prevent damage to the cable.

20. Cables shall enter equipment and foundations thru cable entry openings, chase ways, etc. that have been specifically designed and approved for cable entrance or through cable entrance pipes, as specified in 16897.

21. All wires shall be terminated in conductor order. Individual cable conductors shall be identified at each cable termination with plastic tags as specified above. All spare conductors in each cable shall be terminated and identified.

22. All cable entrance openings in equipment enclosures and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Dry sand shall be used to fill openings, chutes, risers. (Digging below the riser will release the sand) Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe, or duct bank. All spare conduits shall be sealed or plugged in an approved manner.

23. All cables shall be potheaded, tagged and terminated. Tags to identify cables shall be of plastic material. Tags shall be lettered to correspond with the cable destination and number of conductors in the cable. The tag shall be applied at the cable entrance in a manner to be easily read. In addition, all cables shall be tagged within each manhole, each enclosure, and on each side of any barrier the cable passes through. Cables shall also be tagged at aerial exits from conduit risers. The type of tag to be used shall be as described in Section 16897.

24. Wherever multiple conductor cables are terminated, the outer jacket of the cable shall be carefully removed to the point of cable entrance. Only approved cable jacket cutting tools, specifically designed for the purpose, with a positive means of setting and controlling the depth of cut into the jacket will be permitted. Razor instruments shall not be used. All conductors shall be inspected for damaged insulation immediately after removal of outer jacket and before tape is applied.

25. Cables shall be potheaded at termination points. The outer sheath shall be carefully removed to within 3”-12” of the cable entrance. Any bronze or metal type shielding, not used for grounding shall be nipped off and the edges bent outward away from the conductors. This shall be followed with several wrappings of 30 mil rubber tape (Scotch 130C) and two layers of 8.5 mil vinyl tape (Super 88) as manufactured by the 3M Company or an approved equal.

26. Excess cable slack shall not be left at terminal boards. Cable shall be cut so any wire within the cable can reach the furthest terminal designated for that cable then neatly trained back into its allotted terminal. Provide sufficient slack in wire or cable conductors at all terminating posts to enable three reterminations of the conductor due to broken eyelets without reservicing or repotheading the cable.

27. Train cables to farthest end of terminal board from entry point and then fan out wires, providing sufficient slack in cable conductors at all terminating points, to allow three re-terminations of each conductor due to broken eyelets without re-servicing or re-pot heading the cable.

28. In certain types of installation, the cable cannot be constrained; therefore, ample cable slack shall be provided for additional flexibility due to vibration of such equipment.

29. Wires and cables shall be installed (Dressed) in a neat, workman-like manner. Wires and cables in trays or in toughs shall be laid therein and not pulled into same. The cables shall be arranged to allow free access to all cables for maintenance. Wires and cables shall be installed with a minimum amount of cross-over in the trays and troughs and shall not be pulled tightly around bends. All wires and cables shall be protected from abrasion and sharp edges.

30. All conductors shall be eyed (solid only), or terminated as specified in Section 16897, insulation shall be removed carefully to ensure the conductor is not nicked or damaged.

31. All conductors including spares shall be identified (tagged) and terminated. The type of tag used for identification shall be as described in Section 16897.

32. Fiber optic cable shall be looped behind the main terminal board for future termination into a fiber slack enclosure located on the adjacent wall - leave sufficient slack of at least 50 feet. The innerduct shall be cut within 3-12” of the cable entrance.

33. Seal all openings in equipment housings during construction and upon completion to prevent weather and rodents from entering.

B. Underground Buried Installation

1. FRE, PVC or GRS conduit shall be used for all underground cable installations as shown on contract drawings and these specifications.

2. Underground cable installation shall be in FRE, PVC or GRS conduit, buried a minimum of 36” below top of tie or 30” minimum cover depth outside of the tie area. Conduits under track and across roadways shall be GRS.

3. Cables shall not cross one another when they are pulled into a conduit or pipe and care shall be taken not to have the conductors pulled tight or kinked in conduit fittings or boxes. All cables to be installed in the same conduit shall be pulled and installed simultaneously.

4. The track bed and ballast shall be protected from contamination during cable installation, and shall be restored to the existing condition after cable installation. Plastic tarps and plywood shall be used to prevent ballast contamination.

5. Where buried cables enter a concrete foundation, junction box, or case, the Contractor shall coil five feet of slack for each cable below the foundation or pedestal. The conduit end shall be sealed to prevent water penetration and the cable coil shall be encased in a minimum of three (3) inches of sand. Cable marker tape shall also be installed over top of the cable coil at a depth of one (1) foot below the finished grade.

6. Where signal, communications or track cables are installed in the same trench as, or are required to intersect low voltage power cables, these cables shall be installed such that the distance between such cable and the low voltage power cable shall not be less than 12 inches, while maintaining the cover depth of not less than 30 inches for the cable. The 12 inches between any intersecting direct burial cables of different voltages as specified herein shall be filled with sand to a distance of two feet from each cable from the point of intersection.

C. Non-Buried Installation

1. Installation in Cable Trays or Prefabricated Cable Troughs - Cable installed in cable trays or prefabricated cable troughs shall be laid and not pulled in place. Cables installed in trays and troughs shall have a minimum amount of crossover and shall not be pulled tightly around bends.

2. Installation in Conduit

   a. All above ground conduit shall be galvanized rigid steel (GRS). When GRS conduit risers transition into the ground, GRS to FRE conduit adapters are to be installed 3” (minimum) to 5” (maximum) above grade.

   b. Cables shall not cross one another when they are pulled into a conduit or pipe and care shall be taken not to have the conductors pulled tight or kinked in conduit fittings or boxes. All cables to be installed in the same conduit shall be pulled and installed simultaneously.

3. Aerial Cable Installation

   a. Runs of 3/8 inch, extra-high strength (EHS), Type C galvanized messenger wire shall be used for supporting signal, communications and electrical cable. The Contractor shall furnish and install all necessary components for the aerial cable support system in the locations shown on the Contract Drawings.

   b. The Contractor shall perform all sag and tension calculations for messenger wire loadings per the National Electrical Safety Code (NESC).

   c. Messenger wire shall be dead-ended using turnbuckles and strand vises. All ferrous messenger support hardware shall be hot dipped galvanized.

d. A cable bundle supported by a single messenger shall not exceed 4 1/2” inches in diameter. Wherever cables are to be installed on messenger would make a bundle exceeding 4 1/2” inches in diameter, the Contractor shall provide additional messenger wire as approved by the Engineer.

e. The radius of cable bends for insulated cable shall be not less than ten times the diameter of the cable. The radius of cable bends for communication cable shall not be less than fifteen times the diameter of the cable. For flat twin conductor cable, the diameter over the major axis shall be used.

f. Where cables leave the messenger to enter cases, conduits or other equipment, the cables shall be securely fastened and anchored to the messenger by extra wrappings of nylon filament rope to prevent cable from slipping or sagging. The wire and cable shall be tied to new messenger in two steps as follows:

1) Temporary tying, which consists of tying the cable close to the messenger wire by means of temporary marline or rope ties, shall be placed sufficiently close together to hold the cable to the messenger without undue sagging.

2) The permanent tying shall be done with approved cable straps and nylon ties. Round metal "S" hooks may also be used to support the cables during forming of the bundle before permanently tying or strapping.

g. Wire and cable shall be fastened to the messenger wire by means of approved cable straps. Straps shall conform to that in use on existing, railroad installations. The maximum distance between straps shall be fifteen inches, with additional straps provided to meet special conditions. At points where cables leave the messenger wire to enter terminal or instrument boxes, conduit, or any other equipment, or as directed by the Engineer, the cables shall be securely fastened and anchored to the messenger by extra wrappings of nylon filament rope to prevent cable from slipping or sagging.

4. Cable Transition Areas - Where signal cable runs change from one type of installation to another, such as from messenger mounted to duct bank installation or into the track bed, the cable in transition area shall be installed in GRS conduit risers or an enclosed prefabricated GRS or stainless steel raceway.

3.2 TESTS

All installed external cable shall be tested in accordance with requirements of Section 16898 - Signal System Tests of these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for external signal cable but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the external signal cable work will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16809

AUTOMATIC HIGHWAY CROSSING WARNING SYSTEM LAYOUTS

PART 1 - GENERAL

1.1 DESCRIPTION

The work to be done in this Section consists of furnishing materials and equipment not supplied by others and installing automatic highway crossing warning system layouts as specified herein and shown on the Contract Drawings.

1.2 QUALITY ASSURANCE

A. Automatic highway crossing warning system layouts shall meet the requirements of the applicable sections of the AREMA Signal Manual, MUTCD Part 8 and be in compliance with the latest Rules, standards and instructions of CFR 49 Part 234 (FRA) where the requirements do not conflict with these Specifications.

B. The Contractor shall test and inspect the equipment prior to installation.

1.3 SUBMITTALS

In accordance with the requirements of Section 01300 – Submittals, the Contractor shall submit a description of materials and methods of installation to be furnished under this section.

1.4 DELIVERY, STORAGE AND HANDLING

A. Prior to shipment, all parts of the automatic gate crossing mechanism that are not painted or made of non-corroding material shall be coated with an approved grease to prevent corrosion. All unused threaded outlets shall be plugged or capped.

B. LED’s shall be packaged separately from flashing light units in which they are to be used.

C. All material provided and storage under this section shall be protected against damage during handling and shipment and shall be secured against loss during storage. Comply with the provision of Section 16801 – Basic Technical Requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. All equipment specified herein shall be manufactured by one manufacturer, Western Cullen Hayes, or approved equal in entirety where practicable, so as to ensure proper integration with components supplied by the Authority to the contractor into a complete highway crossing signal layout. All equipment specified for AHCW layouts shall be made of aluminum insofar as practicable.

B. The Contractor will furnish and install railroad crossing signs, as hereinafter described at all public and private highway-rail grade crossings as shown in MUTCD Part 8.

1. Signs shall be standard circular RXR signs (MUTCD W10-1), in accordance with the Manual of Uniform Traffic Control Devices (MUTCD). In addition to roadway signs, roadways shall have pavement marking as shown in MUTCD on figures 86-B and 87-B.

2. Railroad Crossing Signs (MUTCD R15-1, crossbuck) shall be white reflex-reflective sheeting on sheet aluminum with the words `RAILROAD CROSSING' in black letters, in accordance with MUTCD, figure 8B-2.

3. Number-of-Tracks signs (MUTCD R15-2P) where required for more than one track crossings, shall be constructed of aluminum alloy and be corrosion resistant. Black letters on a white background shall be of reflex-reflective sheeting or sheet aluminum.

4. Emergency notification signs MUTCD I-13 shall be installed as prescribed in section 8B-5 of the MUTCD. Information shall be obtained from the operating railroad.

2.2 FLASHING LIGHT SIGNAL EQUIPMENT

A. The Contractor shall install mast mounted flashing light signals as shown on the Contract Drawings. The flashing light signal layout shall be equipped with a standard Railroad Crossing sign, and where required, bells, and multiple track signs, as shown on contract drawings.

B. The flashing light signal shall be 12 inch Light Emitting Diode (LED) assemblies in accordance with these specifications and also conform to AREMA Signal Manual, Part 3.2.35. The lamp receptacle or terminations shall be provided for LED maintenance and replacement.

C. Each lamp housing shall be constructed of cast aluminum in accordance with AREMA Part 3.2. The housing shall be equipped with a door with front access, hinged at one side with a weatherproof seal. A ventilation opening shall be provided at the bottom of the housing and covered with brass, or copper, wire screen. A sidelight shall be provided on both sides of the lamp housing complete with gasket, lens, and retainer.

D. Each light unit shall be equipped with 24-inch backgrounds with visors.

E. Flashing light assemblies shall consist of various configurations of back-to-back and single-direction flashing light signals as indicated on the Contract Drawings. 30-inch spacing is required per MUTCD and AREMA regulations. Additional mounting hardware may be required in some instances.

F. Electronic Highway-Rail Grade Crossing Pedestrian bell shall conform to AREMA Signal Section 3 Manual, Part 3.2.61. The electronic bell(s) shall be installed at each crossing as indicated on Contract drawings.

G. The base section for all ground mounted high signals shall be a split base to accommodate an aluminum 5-inch mast. The split based junction box will have sufficient amount of AREMA terminals on each side to properly

install all cable wires. Circuits of 110 volts or more will have insulated nuts installed. The dimensions of the bolt hole centers in the base shall be the manufacturer's standard for ground mounting on foundations.

H. Flashing light signal assemblies shall be, Western Cullen Hayes (WHC) Model A-479, or approved equal. One spare retrofit 12” LED light unit shall be provided for every four lights at all crossings and stored within the crossing shelter for maintenance purposes.

2.3 NOT USED

2.4 AUTOMATIC HIGHWAY CROSSING WARNING GATES

A. The Contractor shall install automatic highway crossing warning signals complete with gate mechanism, gate keepers, gate arm, counterweights, LED gate arm lights, high-wind brackets, mast mounted flashing light units, railroad crossing signs, extension brackets for signs, and, where required, bell(s) where the Contract drawings do not require a bell, the signal mast shall have a pinnacle and Number-of-Tracks signs, together with all necessary hardware as specified herein, in accordance with AREMA Signal Manual, Part 3.2.15, and as shown on the Contract Drawings.

B. The ground-mounted mast for supporting a gate mechanism shall be constructed of five inch aluminum pipe, 16 feet long complete with pinnacle cap and cast aluminum double split base junction box. Junction boxes shall be provided with AREMA terminals, gaskets, and provisions for padlocking on both sides. Cantilever mounted gate mechanisms shall include all the appurtenances as the ground mounted mast gate. All special gate hardware for cantilever supported gates shall be ordered with the cantilever assembly as manufactured by the cantilever supplier.

C. The gate mechanisms shall be supplied with an internal wiring diagram protected by a plastic laminate and shall be fastened to the inside of mechanism cover. Binding posts, nuts, washer and insulators shall conform to AREMA Signal Manual, Part 14.1.11

D. The highway crossing gate mechanism shall be Western-Cullen-Hayes, model 10 layout with 3597 mechanism. No substitute will be allowed. Any highway crossing gate mechanisms to be ordered by the contractor must be approved by the MBTA to ensure the current MBTA approved model is being ordered, currently model # M-10-MBLS2810

E. The general design, painting and striping of the gate arm shall conform to AREMA Signal Manual, Part 3.2.20 or 3.2.24. The striping shall consist of 16-inch alternate reflectorized red and white stripe on both sides of the arm. The arm shall be constructed of non-conductive fiberglass and be designed to ensure reasonable durability and rigidity to prevent undue sway or whipping. The clearance between the gate arm and any fixed portion of the assembly shall be a minimum of two inches.

F. The highway crossing gate arms shall be of sufficient length to extend to within one foot of the centerline of the roadway but in no case less than 90% of the roadway width and provide a minimum clearance of two feet from overhead wire and cable.

G. All roadway gates shall be equipped with high wind support devices. The wind support devices shall be as specified in AREMA Signal Manual, Part 3.2.22.

H. All roadway gates except those mounted on cantilevers shall be equipped with self-restoring gate arm devices. The self-restoring gate arm devices shall be as specified in AREMA Signal Manual, Part 3.2.23 except they shall operate with a gate 32 feet or less in length. The gate arm devices shall be manufactured by Western Cullen Hayes “Gate Gard”, National Electric Gate Co. “Gate Saver”, and General Signal Industries “Gate Keeper” or approved equal.

I. Ten volt weatherproof, bi-directional LED gate arm lights shall be provided in accordance with AREMA Signal Manual, Part 3.2.40 with highway crossing red lenses. Gate arm lights shall be adjustable to permit focusing of lights at gate installations parallel to the tracks but not perpendicular to the roadway.

J. A mechanism support shall be furnished with each gate mechanism. The mechanism support shall provide a base upon which the gate mechanism rests and shall support the weight of the mechanism when it is necessary to swing the mechanism and gate for repairs. Mechanism support shall be similar to WCH 3565-380A, or approved equal, and shall be complete for mounting on a 5" pipe.

K. Crossarms for flashing light units shall be in accordance with AREMA Signal Drawing, Part 3.2.51, as approved by the Engineer.

PART 3 - EXECUTION

3.1 FLASHING LIGHT SIGNAL UNITS INSTALLATION

A. A hole shall be factory drilled in the mast for the bottom crossarm. The center line of the hole shall be located so that, when the crossarm with light units is attached thereto, the center of the lens of the light unit shall be seven feet, ten inches above the top of the foundation. Holes for additional crossarms, when required, shall be located in the field after the bottom crossarm has been secured to the mast. The location and drilling of the hole shall result in the centerline of the additional light units to be 23 inches above the centerline of the lower light unit.

B. Underground cables shall be installed within the mast and terminate in the split base junction box.

1. Wiring for the flashing light units and the bell shall be, No. 10 AWG in accordance with the requirements of AREMA Signal Manual, Part 10.3.1.

C. Where additional light units are used, wiring for these units shall multiple off the wiring in the next lowest crossarm junction box.

D. Wiring for bells shall go directly from the bottom junction box to the bell.

E. Terminations for flasher unit and bell wiring shall be solderless compression type terminals.

F. With ac power off and standby battery in a fully charged condition, the lamp voltage shall be adjusted to nine and one-half volts (measured at the lamp) by varying the resistor for the flasher unit; then, with ac power on the lamp voltage (measured at the lamp) shall be adjusted to the same voltage. Lamp voltage adjustment hall be in accordance with Operating Railroad C&S-1 requirements.

3.2 NOT USED

3.3 AUTOMATIC HIGHWAY CROSSING WARNING GATES

A. The gate arm tip light shall be steadily illuminated and the other gate arm lights shall flash in unison with the mast or cantilever mounted lights.

B. Sidewalk gate lights shall be steadily illuminated.

C. Sidewalk gate lights shall be adjustable for installations not perpendicular to the tracks.

D. Gate arm counterweights shall be adjusted in accordance with the manufacturer's standards for the length of gate arm specified.

E. Masts shall be securely fastened within the junction box base in manner such as the distance between the split halves of the base shall be equal when tightened. (Ground mount gates)

F. The base shall be securely fastened to the concrete foundation with the hardware provided for that purpose.

G. The mast shall be plumb when the base assembly is fastened to the foundation. Shims, spacers, or other fillers shall not be used to level and plumb highway crossing warning gates.

H. Gate operating mechanism, including counter-weight arms, shall be securely fastened to the mast with the hardware provided for that purpose.

I. The mechanism shall be located on the pole in a position that shall allow for the gate arms, when in the down position, to be not more than four feet - six inches, nor less than three feet - six inches, above the crown of the roadway.

J. Underground cables shall be installed in the split base junction box. The cables shall be pot headed, tagged and terminated as specified in Section 16801.

3.4 TESTS

The Contractor shall coordinate and assist the operating railroad in testing the Automatic Highways Crossing Warning layouts. Testing shall be in accordance with the approved Installation Test Procedure and in accordance with Section 16898.

PART 4 – MEASUREMENT AND PAYMENT

4.1 GENERAL

B. No separate measurement will be made for automatic highway crossing warning system layouts but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary

to accomplish the automatic highway crossing warning system layouts will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16825

CONDUIT SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies furnishing and installing various types of conduits and duct bank systems to include conduit, concrete encased duct banks, electrical manholes and hand holes and associated appurtenances as specified herein and as shown on the Contract Drawings.

B. Contractor shall develop detailed work plans for all work items pertaining to installation of items specified in this section. Contractor shall conduct a survey to confirm location of all existing utilities, drainage systems, and any other items that may interfere with or be impacted by installation of cable, conduit, and duct banks.

1.2 QUALITY ASSURANCE

A. Workmanship shall conform to the best modern practices for a rugged, long-lived, safe installation required for a public transportation system. Materials to be installed shall be provided new and of the highest commercial grade as specified.

1.3 SUBMITTALS

A. The Contractor shall submit the following for approval:

1. Manufacturer’s catalog cuts and descriptive literature for all materials as specified herein and as shown on the Contract Drawings.

2. Detailed installation drawings

3. “As-Built” drawings, prior to Authority acceptance.

1.4 Delivery, Storage and Handling

A. Materials shall be protected from damage throughout delivery, storage and handling. Comply fully with the requirements of Section 16801 Basic Technical Requirement.

B. Damage to trough material, resulting from improper handling by the Contractor shall require the Contractor to replace all damaged material with new material at no additional cost to the Contract.

PART 2 - PRODUCTS

2.1 ELECTRICAL MANHOLES/HANDHOLES

A. General

1. Manhole structures cast-in-place concrete shall conforming to the requirements of Section 03300, or precast pre-stressed concrete conforming to the requirements of Section 03314, at the option of the Contractor with the Engineers approval.

2. Backfill material shall conform to the requirements of Section 16806.

3. The Contractor shall provide concrete manholes complete with duct openings, sleeves and end bells, formwork, reinforcing steel, pulling irons, manhole frames and covers, concrete work, cable racks and associated items as specified herein and as shown on the Contract Drawings.

B. Precast Units

1. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast electrical manholes. Precast units shall conform to the following requirements:

   a. Concrete for precast work shall have an ultimate 28-day compressive strength of not less than 5,000 pounds per square inch. Manholes may be precast monolithically and placed as a unit; or, they may be of assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. All structures shall be identified with the manufacturer's name embedded in, or otherwise permanently attached to, an interior wall face.

   b. Design for assembled units: Precast structures shall be designed in accordance with ACI-318 and shall be based on the following properties:

      1. Angle of internal friction equals 30 degrees. Unit weight of soil equals 110 pounds per square foot.

      2. Lateral at rest earth-pressure coefficient equals 0.50 above water-table, equals 0.90 below water-table.

   c. Structural design shall conform to AREA and ACI standards and shall include lateral earth and hydrostatic pressures plus live load (Cooper E380) adjacent to or directly over the structure. Design shall also take into consideration stresses induced in handling units. Lifting devices shall be provided for properly handling units.

   d. Mating edges of precast components shall be provided with tongue-and-grooved joints. Joints shall be designed to firmly interlock adjoining components and to provide water-proof junctions. Joints shall be sealed watertight using preformed plastic strip conforming to AASHTO M198, type B. Sealing material shall be installed in strict accordance with the sealant manufacturer’s printed instructions.

C. Miscellaneous Items

1. Pull eyes shall be steel eye bolts, set in the manhole walls. They shall be located opposite the duct bank or conduit structure.

2. Sump wells shall be provided in all handholes and shall be 12 inches square and 4 inches deep.

3. Manhole sections shall conform to AASHTO M199 specification, except as modified herein.

4. Reinforcement steel shall conform to the requirements of Section 03300.

5. Manhole frames and covers shall be heavy-duty cast iron, suitable for H-20 wheel loading. Covers shall be vented for atmospheric testing as shown on the Contract Drawings. Each manhole cover shall be casted with the logo as indicated on the Contract Drawings.

6. All manhole ferrous hardware shall be hot-dipped galvanized after fabrication in accordance with ASTM Specification A123.

7. Cable support hardware shall be provided in each manhole. Support hardware shall consist of hot-dipped galvanized steel cable racks, porcelain cable saddles, hooks, clips and associated items. Cable support hardware shall be manufactured by Cooper Industries, Joslyn Mfg. Co., A. B. Chance Co. or approved equal.

8. Grounding arrangement shall be as shown on the Contract Drawings.

2.2 ELECTRICAL HANDHOLES

A. Handhole structures shall be precast pre-stressed concrete conforming to the requirements of Section 03314

B. Electrical handholes shall be furnished complete with conduit sleeves, reinforcing steel, frames and covers, drain sumps and other associated items as specified herein and as shown on the Contract Drawings.

C. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products.

1. Concrete for precast work shall have an ultimate 28-day compressive strength of not less than 5,000 pounds per square inch. Handholes may be precast monolithically and placed as a unit; or, they may be of assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. All structures shall be identified with the manufacturer's name embedded in, or otherwise permanently attached to, an interior wall face.

2. Design for assembled units: Precast structures shall be designed in accordance with ACI-318 and shall be based on the following properties:

   a. Angle of internal friction equals 30 degrees. Unit weight of soil equals 110 pounds per square foot.

   b. Lateral at rest earth-pressure coefficient equals 0.50 above water-table, equals 0.90 below water-table.

D. Sump wells shall be provided in all handholes and shall be 12 inches square and 4 inches deep.

E. Handhole sections shall conform to AASHTO M199 specification, except as modified herein.

F. Handhole frames and covers shall be heavy-duty cast iron, suitable for H-20 wheel loading. Covers shall be vented for atmospheric testing as shown on the Contract Drawings. Each cover shall be casted with the logo as indicated on the Contract Drawings.

G. Handhole frames, covers and ferrous hardware shall be hot-dipped galvanized after fabrication in conformance with ASTM Specification A123.

2.3 CONDUIT

A. General. Conduits and fittings shall be free, within commercial tolerances, of objectionable lines, bubbles, chipped ends, and other manufacturing defects, that would impair the service of the conduit. The bore of the conduit shall be straight and circular in cross section with smooth interior surfaces free from obstructions and rough and flaky areas. The conduit and fittings shall be free from all substances that may injuriously affect any wire or cable covering. The numbers and sizes of the conduits shall be as shown on the Contract Drawings. At locations where conduits are required governed by these Specifications and as shown on the Contract Drawings, the various types of conduits to be furnished are specified below. Fittings shall be of the manufacturer's standard for the various types of conduits. Expansion joints shall be installed at all bridge expansion joints and as required by the Manufacturer. Expansion joints shall be installed in accordance with the Manufacture’s installation instructions.

B. Rigid Metal Conduit. Rigid metal conduit shall be used at locations as specified within these Specifications and as shown on the Contract Drawings. The types of rigid metal conduit to be used for the various applications shall be as follows:

1. Galvanized Rigid Steel (GRS) Conduit

a. Steel conduit and fittings shall be made of the best grade standard weight steel pipe protected inside and outside by a coat of hot-dip galvanizing. Where sweeps are used, they shall be the long radius type. Steel conduits shall be protected in shipping and handling by approved thread protectors.

b. Galvanize Touch-Up. Where galvanizing is removed by welding or other assembly procedures, touch-up abraded areas with two coats of zinc-rich chromate paint designed for repair of galvanizing.

c. All conduit, couplings, elbows, and nipples shall be UL approved and meets requirements of ANSI C80.1

C. Rigid Nonmetallic Conduit

1. Fiberglass Reinforced Epoxy (FRE) Conduit

a. Fiberglass reinforced epoxy conduit and fittings shall be made of the best standard grade rated for 130 degrees C, UL listed, and shall be approved by the Engineer, and All material shall comply with ANSI/NEMA Specification TC-14B (Inside Diameter). Conduits shall be furnished in twenty foot lengths. Where sweeps are used, they shall be the long radius type,

b. Fiberglass conduit used in concrete encased duct application for trade sizes up to 4" in diameter inclusive shall be standard wall. Fiberglass conduit used in concrete encased duct bank application for trade sizes 5" and larger shall be heavy wall. Fiberglass conduit used in direct burial application shall be heavy wall.

c. Fiberglass conduit and fittings shall be manufactured by FRE Composites, Inc., Champion Fiberglass, Inc., United Fiberglass, Co. or approved equal.

d. Use only approved fitting, adhesives and sealants recommended by the conduit manufacturer.

D. Innerduct. The two inner ducts for fiber optic cable installations required for this project shall be 1-1/4” ID, smooth wall, schedule 40 (HDPE) and shall be colored orange for the active conduit and black for spare. All inner duct splices shall be made by compression sleeves and tool and adhere to manufacturers recommendations.

E. Polyvinyl Chloride (PVC) Conduit. Thick wall polyvinyl chloride conduit, high impact schedule 80, or schedule 40 herein referred to as PVC conduit, shall be furnished per Contract Drawings. Where elbows are used, they shall be the long radius type.

2.4 CONCRETE ENCASED DUCT BANKS

A. Concrete and Formwork

1. All concrete used in duct banks shall conform to the requirements of Section 03300 for ASTM C150, Type II portland cement concrete. All formwork used shall conform to the requirements of Section 03100.

B. Concrete Reinforcement

1. Concrete reinforcement shall be as indicated on the Contract Drawings conforming to the requirements of Section 03200.

2.5 DUCT SPACERS

A. Duct spacers shall be furnished for concrete encased duct banks and direct burial conduit application.

B. Duct spacers shall be made of high impact plastic, designed to maintain a 2 inch minimum spacing between conduits. Spacers shall be capable of interlocking any combination of duct sizes, horizontally and vertically, and all types of duct (PVC, FRE, steel).

2.6 PULL LINE

A. Pull line shall be 3/16" (minimum) in diameter with a tensile strength of 720 pounds (minimum). Pull line shall be of a polypro material, highly visible bright yellow and weather resistant

2.6 BACKFILL

A. Backfill material shall conform to the requirements of Section 16806.

2.7 CONDUIT MARKER TAPE

A. Conduit marker tape shall conform to the requirements of Section 16806.

2.8 GROUNDING

A. electrical manholes and handholes shallbe grounded.

PART 3 - EXECUTION

3.1 EXCAVATION AND BACKFILLING

A. Excavation and backfilling requirements shall be performed in accordance with Section 16806.

3.2 ELECTRICAL MANHOLES

A. Manholes shall be installed on eight inches of compacted crushed stone or gravel borrows as shown on the Contract Drawings. The exact locations shall be determined after careful consideration has been given to the location of existing and/or proposed utilities, drainage systems and grades.

3.3 ELECTRICAL HANDHOLES

A. Handholes shall be installed on eight inches of gravel or special borrow approximately in the locations as shown on the Contract Drawings. The exact locations shall be determined after careful consideration has been given to the location of existing and proposed utilities, drainage systems and grades.

3.4 CONCRETE ENCASED DUCT BANKS

A. General

1. Conduits shall be wiped clean thoroughly before being installed

2. Fiberglass couplings, adapters and fittings for the ducts shall be installed in accordance with the manufacturer's recommendation.

B. Each single conduit of the duct bank structure shall be completely encased in concrete as indicated on the Contract Drawings. The thickness of concrete encasement indicated is the minimum thickness, and may be increased to fit the actual shape of the trench. Duct spacers shall be used to support the conduits both

vertically and horizontally. Duct spacers shall be placed at 5 foot intervals (maximum). Ducts shall be anchored securely to prevent concrete encasement from deforming.

C. The concrete structure and conduits shall be installed with a minimum continuous slope of six inches per one hundred feet. Duct banks shall slope downward toward the manhole; from one manhole to the next or in both directions from a high point between the manholes.

D. Changes in direction of conduit runs exceeding a total of ten degrees, either vertical or horizontal, shall be accomplished by long radius bends which have a minimum radius of curvature of 25 feet, except that manufactured bends may be used at the ends of the run. The long sweep bends may be made up on one or more curved or straight sections or combinations thereof. Manufactured sweeps shall have a minimum radius of 36 inches, or 48 inches as required by the conduit size.

E. During construction and after the duct bank is completed, the ends of the conduits shall be plugged to prevent water from washing mud or other obstructing material into the conduits. Particular care shall be taken to keep the ducts clear of concrete, dirt and any other substance during the course of construction. Where it is necessary to cut a tapered end on a piece of conduit at the site, the cut shall be made with a tool or lathe that is designed to cut a taper to match the taper of the particular conduit that is being used.

F. After the duct bank structure has been completed, a standard flexible mandrel, not less than 12 inches long and approximately 1/4 inch less in diameter than the inside diameter of the conduit, shall be pulled through each conduit. After this, a brush with stiff bristles shall be pulled through each conduit to make certain that no particles of earth, sand or gravel have been left in the line. An approved pull wire shall be installed in each conduit after brushing and the ends shall be plugged in a manner that will positively prevent entry of foreign objects. Pneumatic rodding may be used to draw in the pull line.

3.5 DIRECT BURIED CONDUITS INCLUDING INNERDUCT

A. Direct buried conduits shall be installed as described for concrete encased duct banks, with the exception of the concrete encasement.

B. Where conduit runs parallel the tracks, conduits shall be buried a minimum of 30 inches cover depth below finished grade or ballast. Where conduits pass under tracks, electrical (power and snowmelter) conduits shall be buried a minimum of 48 inches cover depth below top of tie, signal conduits shall be buried a minimum of 30" below bottom of tie.

C. At grade crossings, conduits shall be installed as shown on MBTA Standard Plan 3100 as a minimum. The 9 way shall be installed on the express cable side.

3.6 INSTALLATION UNDER TRACKS

A. Where duct banks or direct buried conduits are to be installed under existing in-service tracks, provide track structure support such that the rails shall not be damaged, and train service shall not be interrupted, except as approved by the Engineer. Such installations shall be completed in a single day, wherever practical.

3.7 CONDUIT MARKER TAPE

A. Conduit marker tape shall be installed over each duct bank or direct buried conduit run as specified in Section 16806.

3.8 CABLES

A. Cables to be installed within the new conduits shall be installed in accordance with Sections 16700 and 16808.

3.9 CLEANUP AND DISPOSAL

A. Immediately upon completion of all work as required by this Section or any segments thereof, and as directed by the Engineer, remove and dispose of all debris and surplus excavated material away from the site.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for conduit system but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the conduit system will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16829

BONDED INSULATED JOINTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work to be done under this Section consists of the associated signal work with the purchasing and installation of bonded insulated joint plug rails in welded rail.

B. Contractor shall test the Bonded Insulated Rail prior to and after installation and once again, after final track surfacing as prescribed by Section 16898.

C. Contractor shall install temporary bonding as needed and prescribed by Section 16830 as approved by the Engineer.

D. The work to install and field weld all insulated joint plug rails required in this Contract shall be performed by a qualified and approved track installation contractor.

E. Insulated joints shall be installed at all locations as shown on the Contract Drawings and as approved by the Engineer.

1.2 SUBMITTALS

Contractor shall submit to the Engineer a copy of the test form to be used and type test equipment with calibration date for approval.

In accordance with the requirements of Section 01300 – Submittals, the approved Track Contractor shall submit the following to the Engineer for approval:

A. Calibration certificates for all testing equipment used to perform the tests specified herein;

B. The proposed method of packaging, handling and loading all track appurtenances and other track material for approval;

C. Working drawings showing the proposed method and equipment for handling and installing bonded insulated joint plug rails, and conventional plug rails showing locations of field cuts in existing track, and locations of field welds in CWR, and length of rails, for review and acceptance prior to the commencement of work;

D. Prior to the initiation of thermite welding, submit detailed specifications showing the proposed quick preheat thermite kit, method and procedure for thermite welding. The specifications shall comply with these Specifications and that of the weld kit manufacturer, and shall include the name of the weld kit manufacturer and details of the following operations:

1. Rail preparation;

2. Rail end spacing, tolerances, and procedure to maintain rail gap during the welding operation including the type of hydraulic rail puller and profile rail grinder;

3. Rail alignment, including the type of alignment beam system;

4. Placing and securing of prepared molds;

5. Preheating of rail, including method, temperature, and time;

6. Crucible tapping procedures, including duration of weld an cooling time;

7. Trimming and grinding of weld.

E. Submit a complete and current record of all field welds showing the following for each weld:

1. Location by station, track designation and rail;

2. Date and time;

3. Rail weight and section, mill brand, year rolled, heat number;

4. Name of manufacturer of field weld kit used;

5. Air temperature, rail temperature and approximate weather conditions;

6. Rail gap to nearest 1/16 inch;

7. Track alignment and construction (curve, tangent, grade, etc.);

8. Name of Engineer or authorized representative present;

9. Name of Contractor's foreman present.

F. Submit for approval procedures for adjustment of CWR and rail anchoring prior to commencing work. Also, provide a site specific record of work on a daily basis which shall include the following:

1. Location by engineering station, track designation, and rail;

2. Date and time;

3. Air temperature, rail temperature and weather conditions;

4. Rail gap at time of anchoring to nearest 1/16 inch;

5. Adjustment applied (type and movement).

G. Submit the following for review and approval by the Engineer:

1. Sample thermite field welds and their certified qualification test and inspection results;

2. Supervisor and field welder's qualification certifications for each welder who will perform work on this Contract. Weld supervision and all welders shall be required, upon request of the Engineer, to submit their qualifications during the duration of the project;

3. Certification that persons who shall perform ultrasonic testing of field welds have previously tested a minimum of 250 welds;

4. Certified ultrasonic inspection results for all field welds;

5. Design of bonded insulated joint plug rails.

1.3 QUALITY CONTROL

A. General

1. Perform all field weld hand testing and inspection at no additional cost to the Contract.

2. All field weld hand testing and inspection shall be performed by an approved certified independent testing laboratory. The Engineer may audit the operations to ensure that the inspection and test are being performed in accordance with approved procedures and in compliance with these Specifications.

3. To be accepted, all rail, welds, and track must fulfill all the requirements of these Specifications.

B. Field Weld Qualification Inspection and Testing

1. Prior to field welding, the welds, and each welding crew shall be qualified as specified below. Welding crews shall prepare, in accordance with the methods and procedures for thermite field welding submitted and approved under Article 1.02 of this Section, at least three samples of each type of thermite weld; heat treated rail welded to heat treated rail, heat treated rail welded to control cooled rail, and control cooled rail welded to control cooled rail. Each welding crew shall perform at least one of each type of the sample welds. The sample welds shall join two pieces of rail a minimum of 30 inches in length each.

2. Test three sample welds from each type of rail, if required by the Engineer, as follows:

   a. Perform the Rolling Load Test as specified in Article 1.03.B.3 of this Section on one sample weld from each type of rail

   b. Perform the Slow Bend Test specified in Article 1.03.B.4 of this Section on a second sample weld from each type of rail.

   c. Perform the Hardness Test specified in Article 1.03.B.5 of this Section on a third sample weld from each type of rail.

   <u>Rolling Load Test</u>

   a. Test one sample weld from each type of rail on a 12 inch stroke rolling load machine.

b. Welds tested under this Article shall sustain without failure not less than 2 million cycles of repeated loadings of a 44,000 pound wheel load.

Slow Bend Test

a. Subject a second sample weld from each type of rail to the Slow Bend Test described in the Proceedings of the AREA, Volume 68.

b. The acceptance criteria for this test shall be a minimum deflection of 1 inches and 100,000 pounds per square inch modulus of rupture.

Hardness Test

a. Longitudinally cross-section a third sample weld of each type of rail for a distance of one foot each side of the weld, micro-etch and test by the Brinell Hardness Testing method using a 150 kgf diamond sphero-conical penetrator.

b. Test the rail for hardness on the sectioned face at points on a grid pattern of 1/8 inch increments for one inch on each side of the centerline of the weld, and on a grid pattern of 1/2 inch increments beyond until the hardness readings coincide with the hardness of the parent rail metal.

c. Inspect the micro-etched section for compliance with field weld requirements of full penetration, complete fusion and internal defects specified herein.

d. The weld materials and the rail one foot away from the weld shall have Brinell hardness numbers between 248 and 280.

3. Approval of the weld kit, welding process, and welding crews will depend upon all sample welds satisfying the specified requirements. Should any sample weld fail to satisfy the specified requirements, the welding process, the welding crew, or both, will not be qualified for the work.

4. Employ a supervisor and welders for each welding crew, trained and certified for the performance of thermite field welds by the manufacturer supplying the weld kits. Should any supervisor of the welding crew be replaced during the work the welding crew shall be re-qualified under the new supervisor. Welding supervision or the welders shall be required to show proof of certification as requested by the Engineer.

5. Prior to performing welds in specified work, satisfactorily qualify the welds and welding crew as specified herein.

C. Field Weld “In-Track “Testing

1. During field welding, the Contractor shall hand test and inspect all field welds as specified herein to ensure compliance of all field welds daily to the requirements of these Specifications.

2. Each field weld shall have full penetration and complete fusion with no evidence of surface or internal fissures, cracks, porosity or slag type defects.

3. Ultrasonic Testing

   a. Inspect all field welds ultrasonically and daily in accordance with the recommendations of the Nov. 29-30 1983 Proceedings of Association of American Railroads (now AREMA) entitled "Railroad Rail Welding" pages 191-205. Weld quality shall meet the requirements of Article 3.04 of this Section.

   b. Identify each ultrasonic test including the engineering station and track and rail identity. Submit a letter of identification with each test to the Engineer, giving comments on any irregularities found in the weld, whether the weld passes or fails the above recommendations and the requirements of Article 3.04 of this Section.

4. Physical Inspection - Visually and dimensionally inspect each field weld daily to determine Conformance with the alignment and finishing tolerances specified herein

5. Defective Welds - Any defective welds detected by the above testing and inspection shall be removed by saw cutting in a new rail not less than 19”-6" in length and installing two thermite welds. All corrective procedures, as above, for the removal of defective welds shall be at the Contractor’s expense.

D. Tolerances - After insertion of bonded insulated joint plug rails, the final established gauge, cross level, super-elevation and vertical and horizontal alignment for the affected track shall be within the following tolerances

1. The deviation from zero cross level at any point on tangent or from designated elevation on curves between spirals may not be more than 1/8 inch,

2. The variation in cross level on spirals in any 31 feet shall not be more than 1/8 inch

3. The difference in cross level between any two points less than 62 feet apart on tangents and curves between spirals may not be more than 1/8 inch,

4. The deviation from designated elevation on spirals may not be more than 1/8 inch,

5. The deviation from uniform profile on either rail at the mid-ordinate of a 62 foot chord may not be more than 1/4 inch,

6. The variation of track gauge shall not exceed plus or minus 1/16 inch unless otherwise directed by the Engineer.

E. Factory Qualification Tests - Bonded Insulated Joints - Plug Rails

1. Electrical Resistance Test - A rail joint shall be assembled in accordance with manufacturer's recommendations and supported on non-conducting material. With 500 volts dc applied to the rail across the bonded insulated joint for a duration of three minutes, the current flow through the joint

should be measured to the nearest 0.01 micro ampere. The minimum acceptance resistance for the test shall be 10 megohms. With 50 volts AC applied to the rail across the bonded insulated joint for duration of three minutes, the impedance shall be measured with an accuracy of plus or minus 2%. This test shall be repeated three times, once with a frequency in the range from 20Hz to 100Hz, again with a frequency in the range from 200Hz to 1000Hz and again in the range from 2000Hz to 10 KHz. The minimum acceptable impedance for any of these tests shall be 10,000 ohms.

2. Rolling Load Test - The rail joint used in the Electrical Resistance Test shall be mounted on a 33 inch stroke rolling load test machine supported on 36 in. centers with the joint centered between the supports. Apply a 44,400 pound wheel load on the rail for 2,000,000 cycles and measure and record to the nearest 0.001 in. the deflection of the rail at the centerline of the joint. The deflection at the ends of the joint shall also be measured at every 500,000 cycles. The wheel path shall travel from a point 6 in. from the center of the joint to a point 9 in. outside the opposite end of the joint. Total range of deflection of the joint shall not exceed 0.065 inches during the test and the joint shall show no evidence of failure by bending. The electrical resistance test shall then be repeated and the test results shall be within the acceptance criteria specified.

3. Longitudinal Compression Test - The assembled joint shall be sawn in half where the rails are joined together in a manner which will prevent overheating and damage to the epoxy bond. The cut shall be perpendicular to the centerline of the top of rail.

4. A fixture or device shall be used so that the reaction at the sawn ends occurs only on the face of the joint bars when a load is applied to the centroid of the rail at the opposite end. The load shall be applied in increments of 25,000 pounds, maintaining each load increment until the deflection of the rail stops before increasing the load. The load shall be increased to 650,000 pounds and a record of loading and differential movement of the rail measure to 0.00 in. shall be measured for each increment. The joint shall show no indication of slippage prior to reaching a compressive load of 650,000 pounds and the movement shall be less than 1/8 in. in any direction. The relative position of the rail and joint bar shall be within 1/32 in. of its original value when the load is removed.

5. The Contractor shall submit certification and test results that an insulated joint has passed the qualification testing specified herein.

1.4 DELIVERY, STORAGE AND HANDLING

A. Materials shall be protected from damage throughout delivery, storage and handling. Comply fully with the requirements of Section 16801 Basic Technical Requirement.

1.5 RAIL

A. Shipping. - Load rail and bonded insulated joint plug rails only into rail cars or specially equipped vehicles which are in good order.

B. Handling - Handle rail, bonded insulated joint plug rails and other track material in a manner that will not damage the material in any way.

PART 2 - PRODUCTS

2.1 MATERIAL

A. New control cooled carbon steel rail in 78 foot or longer lengths, shall be furnished in sufficient quantity for the completion of work as indicated.

B. The materials shall be loaded, transported, unloaded and distributed by the Contractor.

C. Furnish quick preheat thermite weld kits.

D. Furnish bonded insulated joint-plug rails, as follows:

1. Provide bonded insulated joints shop fabricated into plug rails for installation into CWR. Plug rails shall be 39'-0" in length.

2. All rail furnished for plug rails shall be fully heat treated.

3. The joint bars shall be 36 inch, full face contact design.

4. Material. Fabricate joint bars from quenched carbon steel conforming to AREA Manual for Railway Engineering, Chapter 4, and Specification for Quenched Carbon-Steel Joint Bars.

5. Configuration. Provide full-face contact joint bars conforming to the configuration of the rail, as required. Joint bars shall be smooth and straight. The inside face of the joint bars shall have insulating material pre-bonded, and be smooth with no branding or stamping.

6. Fabrication Tolerances

   a. Finishing Height. Within plus or minus 1/64 inch of the dimension shown on the approved shop drawings.

   b. Straightness. All portions of the joint bars adjacent to the rail shall be straight within a tolerance of plus or minus 1/32 inch, measured with a 36-inch straight edge.

   c. Length. Within plus or minus 1/8 inch of the dimension shown on the approved shop drawings.

7. Insulating Materials

   a. All insulating materials shall be of high pressure, laminated design, impervious to oil, grease and water, and shall have electrical resistance characteristics equal to or greater than fiber insulation meeting the requirements of the AREMA, Signal Section Specification. End posts shall project 1/4 inch, plus or minus 1/16 inch below base of rail and shall be 3/16 inch thick.

b. Bonded insulated joint to be cemented together with adhesive and bolted together with six high strength, 1 inch diameter bolts. Provide bolts, nuts and flat washers conforming to the chemical and mechanical requirements of ASTM Designation A490, Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints, and having Class 2A and 2B thread fit. Provide a positive means for maintaining the tension in the bolts through in-service vibrations by a prevailing lock nut complying with Industrial Fastener Institute Standard IFI-100 and IFI-101, or approved equivalent. Locate and size the bolt holes in conformance to the drilling as specified in AREA Specifications. Flat washers, if required, shall be hardened A-325 or A-490 and tempered carbon steel.

E. Provide new Pandrol Modified "e" clips for all insulated joints.

PART 3 - EXECUTION

3.1 INSTALLATION OF BONDED INSULATED JOINT PLUG RAILS

A. The Contractor shall install bonded insulated joint plug rails at the required locations within CWR territory.

B. Bonded insulated joints shall be installed as suspended joints and existing crossties shall be re-spaced as necessary to achieve this requirement.

C. Joints created by installation of the insulated joint plug rails shall be field welded by an approved thermite process.

D. Bonded insulated joints at resilient fasteners shall be secured with the modified "e" clips.

E. Rail removed for the installation of the insulated joint plug rails shall be salvaged as specified in this Section.

3.2 REMOVAL OF BONDED EXISTING INSULATED JOINT PLUG RAILS

A. The Contractor shall remove existing insulated joint plug rails and install standard rail at required locations.

B. Removal of an existing insulated joint plug rail shall be accomplished by cutting the plug rail with a rail saw or abrasive cutting disk only, 1'- 6" inside both existing thermite welds, which shall result in the proper salvage of a 36 foot (36') long bonded insulated joint plug rail.

C. The installation of standard running rail shall be accomplished by cutting out the existing thermite welds with a rail saw or an abrasive cutting disk only, 1'- 6" outside both existing thermite welds and installing a 42 foot minimum length of rail which shall be field welded in track by an approved thermite process.

D. Bonded insulated joint plug rails removed from track shall be salvaged as specified.

3.3 ADJUSTMENT OF CONTINUOUS WELDED RAIL

A. Rail Temperature

1. Determine rail temperature by an AREA standard rail thermometer as specified in the current AREMA Manual for Railway Engineering.

2. Determine the temperature of the rail by placing the rail thermometer on the shaded side of the rail base next to the web and leaving it there for not less than five minutes and until no change in its reading is detected.

3. Record rail temperature readings of CWR at the time of rail laying.

B. Adjustment of CWR

1. The Contractor shall obtain records from the Engineer of the installation temperature of CWR at locations where CWR is to be cut.

2. When the rail is cut and the rail temperature is less than the rail temperature when originally installed or if the records are not available the CWR must be adjusted for thermal expansion.

3. Adjustment of CWR shall include removal of rail anchors for 1/4 mile in both directions of cut and expanding rail by either natural or applied heat to obtain zero thermal stress. Any methods for obtaining zero thermal stress shall be approved by the Engineer.

4. Before allowing rail to expand, an appropriate length of rail shall be removed to allow for expansion. This rail end gap (G) shall be determined by the formula:

   G = (t-T) LK, where:

   G = Rail end gap in inches

   t = Zero Thermal Stress temperature (95°Fahrenheit)

   T = Rail temperature in degrees Fahrenheit

   L = Length in feet of rail to be expanded

   K = Coefficient of thermal expansion for steel rail = 0.000078

5. Any alternate method for allowing rail to expand shall be submitted to the Engineer for review and approval.

6. After rail is thermally expanded, weld rail ends, re-apply anchors immediately, recording new adjusted temperature on form to be forwarded to the Authority and the operating railroad. Such form shall identify:

   a. Location of cut by mile post to the nearest tenth

b. Location of cut by rail as N.S.E. or W.

c. Temperature of rail before cutting

d. Temperature of adjusted rail

e. Air temperature

f. Length of rail expanded in either direction

7. Once thermally expanded, joints in CWR shall be field welded immediately.

C. Rail Anchoring Temperature

1. The Contractor shall anchor rail when the temperature is within the zero thermal stress temperature range. When zero thermal stress temperature is obtained, begin anchoring immediately. Rail temperature shall remain within the specified zero thermal stress range until the rail is fully anchored. If the rail temperature deviates from the specified zero thermal stress range, cease anchoring until the rail temperature returns to within the specified range.

2. When rail temperature is below the zero thermal stress temperature range, an approved rail heating device may be used for expanding the CWR to make proper adjustment.

3. During anchoring, it is important to ensure uniform expansion. To control this mark the quarterpoint of strings on a rail and tie plate so the amount of expansion can be accurately determined then make sure the rail expands as follows:

1/4 Point - 1/4 of Required Expansion

1/2 Point - 1/2 of Required Expansion

3/4 Point - 3/4 of Required Expansion

a. In the event the first half of the heated CWR string does not have the required expansion at each quarter point, when heating artificially back the heater over the heated portion, without applying heat and then reheat the rail until the necessary expansion is obtained.

b. The rail shall be fully clipped immediately behind the heater and must be clipped while the rail is within the zero thermal stress temperature range.

4. The temperature of a rail, when being clipped opposite an anchored rail, shall be within plus or minus five degrees Fahrenheit of the temperature of the anchored rail when the anchored rail was anchored.

5. Record the rail temperature and related information during the rail anchoring process. Record the rail temperature every 30 minutes during the anchoring process at the anchoring location.

D. Zero Thermal Stress

1. The Contractor shall install, anchor, join, and field weld CWR to produce zero thermal stress in the rail at 90 degrees Fahrenheit, to 110 degrees Fahrenheit.

2. Zero thermal stress may be achieved by heating. Rail pulling shall not be allowed. All methods for artificially obtaining zero thermal stress must be acceptable to the Engineer. Take care to prevent any damage to trackwork components during any heating process. If any damage occurs, make repairs at no additional costs to the Authority.

3. Vibrate rail during thermal adjustment to relieve internal rail stresses. Continue vibration during the full period of rail length correction. Mechanical vibrators used for relieving internal rail stress shall be of a type acceptable to the Engineer and shall not damage the CWR. Continuous welded rail shall be vibrated whether installed at ambient temperature or distressed artificially.

3.4 THERMITE FIELD WELDING

A. General

1. The Contractor shall join strings of CWR laid in tracks together by the thermite welding process except where insulated joints, are located.

2. Field welds shall not be located within the following area unless approved, or directed, by the Engineer:

    a. Within ten feet of a field weld in the opposite rail;

    b. Within 18 feet of a field weld in the same rail;

    c. Within 18 feet from the center of any bolted joint;

    d. Within 3 feet of a shop weld;

    e. Within 10 feet of a bridge deck;

    f. Within 20 feet of a highway crossing;

    g. On a tie plate.

B. Weld Quality

1. Each field weld shall have full penetration and complete fusion with no evidence of surface or internal fissures, cracks, porosity or slag type defects.

C. Welding Requirements

1. The Contractor shall use approved weld kits that are self-tapping, and require minimum preheating.

2. Rail ends shall be saw cut at right angles to the rail. The Contractor shall clean the surface of the rail for a length of approximately six inches from each end, free of all grease, dirt, loose oxide, scale and moisture. All burrs and lipped metal that would interfere with the proper fit of the molds shall be removed. Torch cutting of rails is prohibited.

3. Prior to field welding strings of CWR, the Contractor shall adjust the length of the CWR strings for zero thermal stress temperature, vibrate the rail to relieve internal rail stresses, and fully anchor the rail.

4. At the time of field welding, the rails shall be aligned to produce a weld which, with respect to alignment, shall be in accordance with current AREA Specifications for Fabrication of Continuous Welded Rail modified to require a slight crown in the running surface to assure a flat surface after the weld has cooled. The maximum vertical offset permissible is 0.015 inch using a 36 inch straightedge. The maximum horizontal offset in the rail head using a 36 inch straightedge is 0.060 inch. The maximum combined vertical offset and crown camber determined using a 36 inch straightedge shall not exceed 0.060 inch.

    a. Negative camber or dip shall not be permitted.

    b. The proper rail end alignment shall be achieved by the use of an approved alignment device designed and manufactured for this purpose. In no case will the use of track jacks or track spikes be allowed for rail end alignment.

5. At the time of field welding the rail gap shall be as specified by the manufacturer of the weld kit. If the rail gap is not within the recommended tolerances for field welding, the Contractor shall un-anchor the CWR strings for 300 feet each side of the rail gap and readjust each CWR string for 300 feet within the specified zero thermal stress range. The Contractor shall re-anchor the CWR before performing a field weld. Should the rail gap on anchored CWR be larger than the manufacturer's recommended gap after the CWR strings have been readjusted for zero thermal stress, the Contractor shall saw a length of rail from one end of one of the anchored CWR's and insert a rail not less than 19 feet long to provide the manufacturer's recommended gap for field welding. At locations where the rail gap is smaller than the manufacturers recommended gap, the recommended gap shall be obtained by sawing a piece from the rail.

    a. Thermite field welding is prohibited when the rail temperature is below 32 F., measured on the shady side of the rail.

    b. When the rail temperature is between 32 F. and 50 F., a hydraulic rail puller, designed and manufactured for this purpose, must be used to maintain proper rail end gap. The puller shall be left in place until the rail has cooled to below 700 F. Any movement of the rail before the weld has cooled to at least 700 F. will result in the weld failing. It is important that the weld is not subjected to a sudden strain by releasing the hydraulic pressure too quickly.

    c. The hydraulic rail puller shall not be used to establish the proper rail end gap.

6. The Contractor shall trim and grind weld to meet the following requirements and as otherwise specified by the manufacturer:

   a. Finish the top and sides of the weld at the rail head to within plus 0.005 inch or minus 0.00 inch of the parent section.

   b. If the field weld is located within three inches of the edge of a rail support finish the weld at the rail base to within plus 0.01 inch or minus 0.00 inch of the parent section.

   c. Finish the web zone and the remainder of the rail weld to within plus 0.375 inch or minus 0.00 inch of the parent section. Finish grind the weld to eliminate visible cracks.

   d. Eliminate notches created by offset conditions by grinding to blend the variations. Remove all protrusions or gouges in the welded area and blend the weld area into the rail contour by grinding in a manner which will eliminate fatigue crack origins. The Contractor shall remove, by grinding, all defects visible to the unaided eye, except if removal by grinding cannot be accomplished without damaging the rail, the Contractor shall remove the weld. The Contractor shall take precautions to avoid excessive pressure during grinding of the weld in order to prevent overheating of the rail surface.

   e. The Contractor shall complete all heavy grinding after the weld has reached the ambient rail temperature, or as recommended by the manufacturer. Removal of the weld upset by the use of a saw or other such device is prohibited.

   f. Finish rail grinding shall be completed prior to the operation of trains over the weld. Finish grinding of the weld shall be accomplished with an approved rail profile grinder. The use of hand held grinders is prohibited.

7. Thermite field welds shall be made in accordance with, and shall not deviate from, the manufacturer's recommendations and AREA Chapter 4. Short cuts in the recommended pre-heating process are prohibited.

8. Welding during inclement weather such as rain, mist, snow, etc. is prohibited.

3.5 TRACK ALIGNMENT AND GAUGE

The installation of plug rails shall not disturb existing vertical, horizontal track alignment, or track gauge. Should the Contractor alter or disturb track alignment or gauge while conducting the work the track shall be repaired to the required Authority tolerances at no additional cost to the Authority.

3.6 SALVAGE

The Contractor shall recover all bonded insulated joint plug rails and conventional lengths of rail removed from track. This material shall be properly loaded, transported, unloaded and neatly stockpiled at a location to be determined by the Engineer.

3.7 TRACK USAGE

No work under this Section shall be performed without proper authorization from the MBTA/OPRR and Engineer.

3.8 TESTING

The insulated plug rail shall be tested prior to and immediately after installation and after final track surfacing. Testing will following the procedure set forth in Section 16898. Submit all test results to Project Engineer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for bonded insulated joints but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the joints will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16830

RUNNING RAIL BONDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work of this Section shall include furnishing and installing all rail bonds, fouling bonds, track circuit connections, and all other materials required for bonding of track circuit joints and track circuit connections as specified by this Section and shown on contract drawings.

B. Rail track joints shall be bonded with welded railhead bonds per AREMA Section 8.1.30 and applicable sections of this specification and with Engineer approval.

C. Track connections shall be non-insulated stranded type.

1.2 QUALITY ASSURANCE

A. Material, equipment and systems procured for this Contract shall be produced under control of a formal Quality Assurance Program to ensure an acceptable level of quality of the equipment provided. Furnish certificates of Quality Assurance Programs as requested by the Engineer.

B. Welded Bonds, track connections, frog bonding and track switch bonding shall be in accordance with the requirements of AREMA Section 8.1.20, 8.1.25 and 8.1.30 and Contract drawings and as coordinated with the Operating Railroad.

C. The Contractor shall install and test each welded bond and mechanical connector in accordance with the requirements of this Section other sections of these Specifications and manufacturers recommendations.

1.3 SUBMITTALS

A. In accordance with the requirements of Section 01300 – Submittals, submit catalog cuts and descriptive literature for the following:

1. Material composition, electrical and mechanical characteristics for all signal bonds.

2. Field installation procedures for welded signal bonds,

3. Field test procedures for welded signal bonds,

4. All devices for securing and protecting running rail bonding,

5. Plan showing detailed final design for bonding to assure that all signal bonds are properly connected electrically.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Provide bonding materials and track circuit connectors, as manufactured by Erico or approved equal. Provide bonds and materials manufactured for welding by the exothermic process. All bonds, bonding, materials and types of molds shall be as approved by the Engineer. The type of bonding required shall be selected for the correct application as follows:

1. Signal Rail Bonds - Provide signal bonds for signal rail sections using rail-head type manufactured for welding application. The bonds shall be 5/16" x 6 1/2".

B. Furnish welding material consisting of copper exothermic mixture employing tin-metal in an amount to effectively constitute 4-1/2 percent to 5-1/2 percent of resulting weld metal. Resulting weld metal shall be of high electrical conductivity with minimum tensile strength of 39,000 pounds per square inch. Determine tensile strength by performing tensile tests on 1/2 inch nominal diameter tensile specimens (without flaws) cast in graphite molds.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Bonding shall be installed at locations shown on the Contract Drawings, and as specified herein. All components of the track work shall be bonded in accordance with the approved plans in order to establish electrical continuity and conductive capacity for proper operation of signal system track circuits.

B. For all rail-joint bonds where the bond is to be applied, shall be ground clean with a reinforced grinding wheel, of a type as recommended by the bonding material manufacturer. The use of vitrified grinding wheels will not be allowed. After grinding, the surface shall be cleaned with an approved non-toxic solvent to remove all traces of grease and dirt.

C. After the surface has been ground and cleaned, the surface shall be heated to drive out any moisture. The cable bond shall then be welded by the approved exothermic process in such a manner as to ensure a thorough mechanical and electrical connection.

D. The casting of the test specimens shall be by the direct reduction of the exothermic mixture and the flowing of the weld metal into a graphite mold to form the one-half (1/2) inch diameter specimens.

E. At his expense and before beginning work on these bonds, the Contractor shall require each welder to weld in the field under conditions similar to those of the regular installation, not less than three complete rail

connections, and as many more as the Engineer considers necessary to determine that the welds are being made satisfactorily. Such welds shall be subject to inspection and test by the Engineer, and his approval as to method and quality of workmanship will depend on the results of these inspections and tests.

F. It is of great importance that each rail connection be thoroughly welded to the rail. To reduce the possibility of any of these welds breaking in service, the Engineer reserves the right to require a test of each weld by hammer and striker, or in any other manner which in the opinion of the Project Engineer is reasonable.

3.2 TESTS

A. The Contractor shall demonstrate that the bonding is in accordance with the requirements of this Section, those as shown on the Contract Drawings, and as specified in AREMA C&S Manual, Section 8.

B. Bonds, welds, or connections installed by the Contractor which are found to be defective prior to acceptance, shall be removed and a new bond shall be installed as art of the work.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for running rail bonding but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the bonding will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16855

INTERNAL WIRE AND CABLE

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies furnishing and installing wire and cable in the signal instrument houses (SIHs), wayside cases, equipment, devices and in enclosures where it will not be exposed to the elements. All intra-rack and rack-to-rack wire and cable shall conform to the requirements of this Section. All required wiring materials shall be approved by the Engineer. Internal wiring for vital circuits shall be in accordance with applicable AREMA Signal Manual unless otherwise specified herein.

B. Stranded wire, including individual conductors of multi-conductor cables covered by this Section, shall be TEFZEL® per Military Specification, MIL-W-22759 and the Specifications contained herein.

1.2 QUALITY ASSURANCE

A. Quality Assurance provisions of the applicable Military Specifications shall be followed in the manufacture of wire covered by this Section. The Contractor shall be responsible for witnessing and reporting the results of any and all required qualification tests. One-half of each qualification sample shall be retained for the Contractor's evaluation and the remaining one-half shall be forwarded to the Engineer for final approval. The Contractor shall be responsible for monitoring the manufacturer's conformance to the quality assurance requirements and the Engineer reserves the right to audit conformance in accordance with the MBTA Standard Specifications.

B. All other work covered by this Section shall be accomplished in compliance with a Quality Assurance Program that meets the intent of the ASQC Standard Cl-1985 General Requirements for a Quality Program.

C. Multi-conductor cables shall be tested to verify conformance with the requirements of this Section as follows:

1. Individual conductors shall be tested per the requirements specified herein for Stranded Wire for General Use, prior to cable assembly.

2. All finished cables shall be placed in water at room temperature. After 48 hours immersion and while still immersed, all conductors shall be tested for breakdown at a voltage of 2,500 volts (rms) for five minutes.

3. Samples of finished cable fabricated from each batch of cable outer sheath material shall be flame-tested per IEEE Standard 383-1974.

1.3 SUBMITTALS

In accordance with the requirements of Section 01300 – Submittals, the Contractor shall submit the following for the Engineer's approval:

A. Complete technical data verifying that the internal wire and cable which the Contractor proposes to furnish in compliance with the requirements of this Section;

B. Qualification samples;

C. Reports of all qualification tests witnessed by the Contractor;

D. Certified test reports of all breakdown tests conducted on finished cable;

E. Certified tests reports of all flame tests conducted on finished cable;

F. Submit a Certificate of Compliance to the requirements of the Specification. The certificate shall list all requirements and shall show a confirmation for each item. The certificate is to be signed by the Contractor’s quality control officer.

1.4 DELIVERY, STORAGE AND HANDLING

A. Materials shall be protected from damage throughout delivery, storage and handling. Comply fully with the requirements of Section 16801 Basic Technical Requirement.

B. Damage to trough material, resulting from improper handling by the Contractor shall require the Contractor to replace all damaged material with new material at no additional cost to the Contract.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Stranded Wire for General Use

1. General Requirements

a. The requirements for TEFZEL®, Okonite, Rockbestos, or approved equal railroad cable supplier wire described herein shall consist of this Specification and the issue in effect of Military Specification MIL-W-22759. Where there is a discrepancy between this Specification and the requirements of the applicable Military Specification, the requirements of this Specification shall govern. The requirements of this Specification shall also be used where the Military Specification refers to "...the requirements of the applicable military specification sheet."

b. All internal stranded wire furnished and installed under this Contract shall be subject to the following requirements:

1) Conductor: Concentric-Lay-Stranded, Annealed Copper per ASTM B-8

2) Coating: Tin or Lead per ASTM B-33 or B-189

3) Insulation: ETFE – Ethylene-Tetrafluoroethylene or E-CTFE - Ethylene-Chlorotrifluorethylene per MIL-W-22759

4) Construction: per Table A.

5) Performance: per Tables B. and C.

TABLE A.

Construction Details

Wire Size (AWG)	Conductor Stranding (Strands x Size)	Maximum Diameter Stranded Conductor (Inches)	Conductor Resistance Maximum @ 20 C (Ohms/1000 Ft.)
22	19 x 34	.033	16.2
20	19 x 32	.041	9.88
18	19 x 30	.051	6.23
16	19 x 29	.058	4.81
14	19 x 27	.073	3.06
12	37 x 28	.090	2.02
10	37 x 26	.114	1.26
8	133 x 29	.173	.701

TABLE B.

Performance Details

Wire Size (AWG)	Minimum Resistance (Inches of Tape)	Weight Support Bracket	Weight (Pounds)	Tension Load (Pounds)
22	26	A	1.0	1.0
20	26	A	1.0	1.0
18	27	A	1.0	1.0
16	28	A	1.0	2.0
14	19	B	3.0	2.0

12	29	B	3.0	2.0
10	36	B	3.0	3.0
8	35	B	3.0	3.0

TABLE C.

Performance Details

Wire Size (AWG)	Mandrel Diameter Life Cycle	Cold Bend (Inches Max.)	Test Load Life Cycle	Cold Bend (Pounds)
22	3/4	1	1.5	3.0
20	3/4	1	2.0	4.0
18	1	1 - 1/4	2.0	4.0
16	1	1 - 1/4	2.0	5.0
14	1 - 1/4	2	2.0	5.0
12	2	2	2.0	5.0
10	3	3	2.0	5.0
8	3	4	3.0	6.0

2. Additional Requirements for Stranded Wire

Type of Insulation	ETFE or E-CTFE	Polyarylene	Polymide Film Tape
Military Specification	MIL-W-22759	MIL-W-81044	MIL-W-81381
Nominal Wall Thickness Size 22-14 AWG	15 mils	10 mils	10 mils *
Nominal Wall Thickness Size 12-8 AWG	20 mils	12.5 mils	12.4 mils *
Temperature Rating	150 C	150 C	150 C
Blocking Qualifications only)	200 C	200 C	200 C
Color	Contractors Option		
Flammability **	pass	pass	pass

Type of Insulation	**ETFE or E-CTFE**	**Polyarylene**	**Polymide Film Tape**
Identification **	30 inch intervals (max.)		
Identification Stripping or Printing Durability	125 cycles (250 strokes) (min.) with 500 grams weight		
Life Cycle	Oven temp. 200 C for 168 hours		
Dielectric Test	2200 volts (rms), 60 Hz		
Accelerated Aging	7 hrs. at 210 C (Quality Conformance Test, Group II; Procedure as in Life Cycle Test)		
Physical Properties of Insulation			
Tensile Strength PSI (min.)	5,000	12,000	24,000
Elongation percent (min.)	125	50	40
Chemical Resistance	Test not required		
Shrinkage at 200 +/- 2 degrees C (inches max.)	0.125	0.125	0.303
Smoke	200 ℃	200 ℃	200 ℃ ***
Thermal Shock			
Cold Bend	-65 ℃	-65 ℃	-65 ℃
Dynamic Cut Through pounds (min.) at 23 degree C with size 20 AWG	90	90	90
Wicking	Test not required		
Abrasion Resistance after Immersion	Same as initial		
Lamination Sealing	NA	NA	230 ℃ 48 hrs
Polyimide Cure Test	NA	NA	required
Resin Coating Durability	NA	NA	****
Humidity Resistance	IR after exposure shall meet initial requirements		
Voltage Rating	600 V RMS	600 V RMS	600 V RMS
Impulse Dielectric Test (100%)	8 KV Peak	8 KV Peak	8 KV Peak
Insulation Resistance	5000 megohms per 1000 ft. (min.)		
Spark Test	Test not required		
Surface Resistance Megohms per inch (min.) Initial and Final	500	500	500

Type of Insulation	ETFE or E-CTFE	Polyarylene	Polymide Film Tape
Wet Diaelectric Test Volts (rms)	2500	2500	2500

* Nominal wall thickness for Polymide film shall be achieved by the following combinations of 50 percent overlapped tape wraps plus an outer 1 mil coating of modified aromatic polymide resin: First wrap. 1/2/.5; Second wrap, .5/1/.5; Third wrap, (Size 12-8 AWG only) .1/1/.1

** As required by this specification

3. Special Requirements for Stranded Wire

a. Vertical Flame Test

1) Single Wire. The test specimen shall be 18 inches in length, and shall be placed vertically within a chamber approximately 2 feet by 1 foot by 1 foot, open at the top and one vertical side (front), which allows a sufficient flow of air for complete combustion, but which is free from drafts. The upper end of the specimen shall be fastened in the chamber by means of a clamp and a weight shall be attached to the lower end of the specimen to hold the specimen taut during the flammability test. The weights shall be the same as those used for the life cycle tests. The specimen shall be marked at approximately 7 inches above the floor of the chamber to indicate where the flame is to be applied.

2) A flame from a Bunsen burner shall be applied for 15 seconds to the specimen. The Bunsen burner shall be positioned below the test mark on the specimen and at an angle of 20 degrees to the vertical plane of the specimen. The Bunsen burner shall have a 1/4 inch inlet, a nominal bore of 3/8 inch, and a length of approximately 4 inches from the top to primary inlets. The burner shall be adjusted to produce a 3-inch high flame with an inner cone approximately one-third of the flame height. The temperature of the hottest portion of the flame, as measured by a thermocouple pyrometer, shall be not less than 955 degrees C ±30 degrees C. The burner shall be positioned so that the hottest portion of the flame is applied to the approximate position of the test mark on the wire. The time of burning and the flame travel after removal of the flame shall be recorded. Breaking of the wire specimens in sizes 24 and smaller shall not be considered as a failure.

3) Bundles. The test specimens shall be prepared by assembling seven single wire specimens, each 14 inches long, into a bundle tied in two places with glass cord or equivalent non-metallic, noncombustible material, 3 inches from each end. The bundles shall be suspended vertically in the test chamber described above. A flame from a Bunsen burner shall be applied vertically to the base of the bundle for 15 seconds. The burner flame shall be adjusted as described for the single wire flame test. The time of burning and flame travel after removal of the flame shall be recorded.

b. Dynamic Cut-Through

1) The dynamic cut-through test shall be performed at room temperature using a tensile testing machine equipped with a recorder which shall be suitable for recording the force in pounds necessary to force a tungsten carbide cutting tool through the insulation of a finished wire specimen. This cutting tool shall have a cutting edge of .005 inch radius of curvature on a 90 degree wedge. The testing machine shall also be equipped with a 12-volt detection circuit designed to stop the testing machine when the cutting edge cuts through the wire insulation and contacts the conductor.

2) One inch of insulation shall be removed from one end of an 18-inch finished wire specimen. The specimen shall be placed on a hard, flat surface and the cutting edge oriented perpendicularly to the axis of the wire specimen. The cutting edge shall be forced through the insulation at a constant rate of 0.2 inch per minute until contact with the conductor occurs. The force measured at the time of contact with the conductor shall be recorded. Four tests shall be performed on each specimen with the specimen being moved forward one-inch (minimum), and rotated clockwise 90 degrees between each test. The cut-through resistance shall be the average of the four test result values.

c. Identification

1) Each stranded wire shall be marked with the following information:

(a) Manufacturer's name

(b) Year in which wire is manufactured

(c) Size of conductor

(d) Type of insulation.

2) The identifying markings shall be permanent and shall be easily readable and understandable.

3) Stranded wires used in multi-conductor cable shall be numbered or color-coded in addition to the basic four-part identification.

B. Internal Multi-conductor Cable

1. The outer jacket shall be fabricated of TPR - thermoplastic rubber and shall comply with the requirements of IEEE Standard No. 383 latest revision. The jacket shall be stabilized for outdoor exposure. The outer sheath shall have a nominal thickness in accordance with IPCEA S-68-516, Table 4-16. The barrier tape shall be .005 inch thick, with a minimum 25 percent overlap. The individual conductors shall be sized to meet 150 percent of the load requirements, but shall be no smaller than size 19 AWG, stranded.

2. Cables shall be made by assembling the individual or twisted pairs of insulated wires into a tight, cylindrical form. Individual or twisted pairs shall be assembled helically and with adjacent layers wound in opposite directions.

3. The makeup of multi-conductor cables specified by this Section shall not exceed thirty or fifty conductors for use with vital or non-vital plug connectors respectively.

4. Multi-conductor cables shall have 10% spare conductors or as shown on Contract Drawings whichever is greater. Reduction in the number of spares is not allowed unless otherwise directed by the Engineer in writing. All spare conductors are to be terminated unless otherwise directed by the Engineer in writing or otherwise specified herein.

5. The cable outer sheath shall be marked with the following information repeated at intervals no greater than 36 inches:

   a. Manufacturer's name

   b. Year of cable manufacture

   c. Number and size of conductors

   d. Type of insulation on wires

   e. Type of outer sheath insulation

   f. Voltage rating.

6. The identifying markings shall be permanent and shall be easily readable and understandable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

Internal wire and cable shall be installed in accordance with the applicable requirements of AREMA C&S Manual, Part 10.4.1 and as specified herein.

1. Wires and cables shall be installed in a neat, workmanlike manner. Cables in trays or in troughs shall be laid therein and not pulled in. Cables shall be installed with a minimum amount of crossover in the trays and troughs and shall not be pulled tightly around bends. All exposed wires and cables entering or leaving equipment racks or housings shall be protected from abrasion by sharp metallic edges.

2. Nylon straps shall be provided and installed for bundling and cabling of conductors where two or more single conductors are exposed in internal rack bundles, cable trays or cable troughs, or whenever wires are to be bundled. Tape shall not be used for this purpose. Straps shall be installed at intervals not greater than five feet along the cable run. Wires of multi-conductor cables exposed by the stripping of the cable jacket for termination’s shall be trained in a neat, workmanlike manner and tied approximately every three inches with nylon straps.

3. There shall be no point-to-point redundancy of wires for increased current capacity.

4. Single conductor No. 14 stranded wire shall be used for interconnecting signal junction boxes and lamp compartments and other miscellaneous equipment, unless other size is shown on the Contract Drawings.

5. Internal Ground wires are to be run separately and shall be colored green.

6. Low voltage wiring, less than 50 volts shall be separated, from wiring carrying more than 50 volts, by a minimum of six inches. Where wiring of less than 50 volts crosses wiring of more than 50 volts it shall do so at right angles. Individual ground wires shall be separated from all wiring by a minimum of 6 inches.

B. Module Wiring

Unless otherwise approved by the Engineer in writing, all module wiring shall be accomplished with solder less connections using stranded wire as specified herein. Minimum wire size shall be No. 22 AWG for stranded wire.

C. Rack Wiring

1. Vital Racks -Unless otherwise directed by the Engineer in writing, all vital rack wiring shall be accomplished with approved solder less connections. Wire for vital rack wiring shall be stranded wire as specified herein, minimum size No. 16 AWG or multi-conductor cables as specified herein.

2. Non-Vital Racks - Unless otherwise directed by the Engineer in writing, all non-vital rack wiring shall be accomplished with approved solder less connections. Wire for non-vital rack wiring shall be stranded wire as specified herein, minimum wire size No. 19 AWG or multi-conductor cables as specified herein.

3. Rack wiring shall be neatly tied into compact bundles. The main bundles and branches shall be secured to the racks in a manner which shall preclude physical damage due to pressure of abrasion and prevent the wire weight from being supported by the wire terminations, connections, or plug connection. The arrangement of the wire bundles and cables shall be such that they do not interfere with visual inspecting, troubleshooting, or repair of the rack-mounted equipment.

D. Rack-to-Rack Wiring

All rack-to-rack wiring shall be routed via the overhead cable trays with one foot of slack between the cable tray and each rack to which the cable or wire is connected.

1. Vital Racks

Unless otherwise approved by the Engineer in writing, all rack-to-rack wiring for factory wired housings shall be accomplished using single conductors tied into bundles to form unjacketed multi-conductor cables. Unjacketed multi-conductor cables shall consist of individual conductors of size 16 AWG or larger wire and shall have a maximum tie spacing of six inches. Internal wiring for vital circuits shall be in accordance with applicable AREMA Signal Manual unless otherwise specified herein. No. 16 AWG 19-strand single conductor flexible wire minimum shall be used for all circuits. Larger flexible stranded wire (No. 14 AWG 19-strand minimum) (No. 10 AWG 27 strand single conductor flex minimum) shall be used for wiring

from underground cable terminating in junction boxes to switch machines and locks as specified herein and as shown on Contract Drawings.

2. Non-Vital Racks

Unless otherwise approved in writing by the Engineer, all rack-to-rack wiring for non-vital racks shall be accomplished using single wire and multi-conductor cables as specified herein. Non-vital plug connectors use shall be minimized and only as required and as specified within these Specifications.

3. Non-Vital Racks to Vital Racks

Unless otherwise approved in writing by the Engineer, all wiring between non-vital racks and vital racks shall consist of single conductors, tied into bundles, between the non-vital rack and the vital rack connection points. These individual conductors shall consist of size 16 AWG or larger wire and shall have a maximum tie spacing of six inches. Unless otherwise approved by the Engineer in writing, all wiring for non-vital circuit energy distribution shall be accomplished using single conductor 19 strand No. 16 AWG. Non-vital intrarack wiring shall be minimum size No. 20 AWG 19 strand single conductor.

Non-vital rack-to-rack wiring shall be single conductor minimum size No. 16 AWG 19 strand wire.

E. Local Panel

Ethernet and special application network wiring shall be as shown on the Contract Drawings.

F. Entrance-to-Instrument Rack Wiring

Wiring from entrance racks to instrument racks shall be accomplished using stranded wire, as specified herein, minimum size No. 16 AWG, and as approved by the Engineer.

G. High Voltage Wiring

Internal wire used in circuits directly connected to the rails and internal wire used in circuits which operate at voltages in excess of 1000 volts shall meet the requirements of Section 16808 - Signal Wire and Cable, as specified herein.

H. Energy Distribution

1. Vital Racks

Unless otherwise approved by the Engineer in writing, all wiring for energy distribution shall be accomplished using single conductor stranded wire as specified herein. Rack wiring shall be accomplished with solder less connections using stranded wire, minimum size No. 14 AWG. Rack-to-rack wiring shall be accomplished with solder less connections using stranded wire, minimum size No. 14 AWG.

2. Non-Vital Racks

Unless otherwise approved by the Engineer in writing, all wiring for energy distribution shall be accomplished using single conductor stranded wire as specified herein. Rack wiring shall be accomplished with solder less connections using stranded wire, minimum size No. 16 AWG. Rack-to-rack wiring shall be accomplished using solder less connections using stranded wire, minimum size No. 14 AWG.

I. Conductor Sizing

All conductors must be sized per the National Electrical Code and to satisfy the load requirements of the equipment and systems provided, but shall not be smaller than the minimum conductor sizes specified herein.

3.2 TESTS

Internal wire and cable shall be tested as specified herein and in accordance with the requirements of Section 16898 – Signal System Tests of these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for internal wire and cable but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the internal wire and cable will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16876

GROUNDING OF EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work of this Section consists of furnishing and installing a grounding system for the equipment housing and all other wayside equipment apparatus, as specified herein and shown on the Contract Drawings and as approved by Engineer.

1.2 QUALITY ASSURANCE

A. Materials and equipment furnished or procured to install under this Section shall conform to all applicable State and local ordinances pertaining to electrical power installations and the latest edition of the National Electrical Code (NEC).

1.3 SUBMITTALS

A. In accordance with the requirements of Section 01300 – Submittals, the Contractor shall submit a description of materials and methods of installation to be furnished under this section.

1.4 DELIVERY, STORAGE AND HANDLING

A. Materials shall be protected from damage throughout delivery, storage and handling. Comply fully with the requirements of Section 16801 Basic Technical Requirement.

B. Damage to trough material, resulting from improper handling by the Contractor shall require the Contractor to replace all damaged material with new material at no additional cost to the Contract.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Ground rods - Copperweld Corp., Burndy, Hubbel, or approved equal.

B. Ground wire

C. Cadweld connections - Erico Corp., Burndy, Hubbel, or approved equal.

2.2 GENERAL

A. Ground rods shall be copper-clad steel. The rod shall be at least 8 feet in length and at least 5/8 inch diameter, unless at metered electrical service which will require a 10’ x3/4 inch ground rod.

B. Sizing of ground wire shall be in accordance with the NEC, except where sizes specified herein or shown on the Contract Drawings are larger than those required by NEC; UL listed, Label A for lightning protection conductors. Grounding cable shall be continuous without joints or splices throughout its length. Ground wire shall be minimum bare, soft-drawn #6 copper wires.

C. All ground wire connections to ground rods will be of the exothermic weld type, no mechanical connections are permitted except internal to shelters and cases at ground buss.

D. A grounding buss of nickel-plated hard drawn pure copper shall be provided in the equipment housings for final external connection as shown on contract drawing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Houses, shelters and cases shall be grounded as described herein and in accordance with the contract drawings, applicable requirements of the National Electrical Code (NEC) and local city electrical codes.

2. The grounding system shall preclude any closed loop grounding arrangements.

3. Ground connection(s) to the track rails or use of the neutral conductors of the AC Power Supply shall not be permitted.

4. Grounding under these specifications will conform to AREMA C&S Manual, Section 11. In cases where these instructions differ, the Engineer will make final decision.

5. Ground wire/cable runs shall be as short and straight as possible and shall not be interrupted by any device. No splices are allowed.

B. Exterior: Equipment Housing Grounding

1. At equipment housings, four ground rods shall be driven into the ground, one near each corner of a structure but in no case closer than 3’ to minimize step and touch potential. At equipment cases, two ground rods shall be driven into the ground, at opposite corners of the structure. The ground rods shall be a minimum of 6 feet apart and shall be driven 6” below finished ground level. A trench, 30 inches deep, shall be dug between the ground rods. Each of the ground rods shall be electrically connected to the others, using the appropriate ground wire and welded using “Cadweld” or an equivalent thermal process. The ground wires shall be placed in the bottom of the trench. The trench shall be backfilled, returning the soils removed during construction of the trench.

2. The housing’s copper ground cables shall be Cadwelded to the ground rods.

3. Ground resistance, as measured by the "Fall-Of Potential" method, shall not exceed 15 ohms. Additional ground rods or chemical enhancement systems may be used to achieve the acceptable value.

C. Interior: Equipment Grounding

1. All housings shall be equipped with a prime ground terminal securely attached electrically to the housing structure and to the made ground network.

3.2 TESTING AND INSPECTION

A. Ground Resistance Testing: Verify that resistance between ground buses and absolute earth, as measured by the "Fall-Of Potential" method, does not exceed 15 ohms without benefit of chemical treatment or other artificial means.

B. Test Reports: Provide test reports to the Engineer upon completion of ground tests that completely describe ground resistance test procedures and test results. Test reports shall be signed by a technician and witnessed by a representative of the MBTA/MBCR.

PART 4 – MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for grounding equipment but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the grounding equipment will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16897

MISCELLANEOUS COMPONENTS AND PRODUCTS

PART l - GENERAL

1.1 SCOPE

The work to be done under this Section consists of the furnishing and/or installing miscellaneous components and products to be used on this Contract. The Contractor shall not install any item without the Engineers approval.

1.2 QUALITY ASSURANCE

A. All miscellaneous components and products used on this Contract shall be:

1. New and free of manufacturing defects;

2. Clearly and permanently labeled with value or type identification.

B. All electrical components shall be rated to operate at power, voltage, current, and temperature levels exceeding by 20-percent those which the components will be subject to in service, unless otherwise specified herein.

1.3 SUBMITTALS

A. Performance data or a sample of each type of component or product proposed as an equivalent to those herein specified shall be submitted.

B. The Contractor shall obtain the Engineer's written approval obtained for any such equivalent type component or product he proposes to use.

1.4 DELIVERY, STORAGE, HANDLING

A. Make provision and be responsible for delivery, storage, and handling of all materials and equipment required of this Contract in accordance with the requirements of these Specifications.

B. Properly package all material, equipments and their components at the manufacturer’s factory before shipment. Replace any material or equipment damage, lost or stolen, at no additional cost to the Contract.

C. Protect all miscellaneous components and products form damage, throughout the delivery, storage and handling.

PART 2 - PRODUCTS

2.1 NOT USED

2.2 NOT USED

2.3 CIRCUIT BREAKERS, FUSES AND FUSE CLIPS

A. Fuses and circuit breakers shall be of suitable capacities to protect the various pieces of signal apparatus from the effects of short circuits or overloads. All circuit breakers and fuses required for the equipment and systems shall be in accordance with these Specifications.

B. Circuit fuses shall be non-renewable, and shall be of the fiber-case, time-lag, fusion type. The circuit breakers and fuses shall be the correct size and rating for circuit current interruption and shall protect the electrical equipment and circuits from short-term and long-term overloads.

C. In dc branch circuits, where fusing is impractical, a protective resistance unit shall be furnished. All fuses shall be centrally located on the power distribution panel and power racks.

D. Fuse clips shall be so constructed that they shall retain their resilience under all installation and service conditions to assure a positive contact between the clips and the fuse.

2.4 DIODES

All diodes to be furnished under this Contract shall carry a JEDEC number or shall be available from more than one manufacturer and shall be used within the published specifications for such number. All diodes shall be silicon type, unless otherwise approved by the Engineer.

2.5 RESISTORS

All resistors, other than those required for electronic circuits, shall be in accordance with AREMA Signal Manual Part 14.2.15.

2.6 REACTORS

All reactors, other than those required for electronic circuits, shall be in accordance with AREMA Signal Manual Part 14.2.20.

2.7 CAPACITORS

All capacitors shall be in accordance with AREMA Signal Manual Part 14.2.40.

2.8 SIGNAL MOLDED TERMINAL BLOCKS

Signal System terminal blocks shall be in accordance with the applicable requirements of AREMA Signal Manual Part 14.1.5.

2.9 SIGNAL TERMINAL BINDING POSTS

Signal System Terminal binding posts, other than those required for supervisory control circuits, shall be in accordance with AREMA Signal Manual Part 14.1.10.

2.10 TERMINAL POST INSULATORS

A. All terminal posts, located on terminal boards in the wayside cases and central instrument house used to terminate 120V or greater shall be provided with a protective insulator.

B. The type of insulator shall be individual for each terminal post, and shall be fire-resistant.

2.11 INSULATED TEST LINK

Insulated test links shall be Type 0255-l0l as manufactured by Western-Cullen-Hayes, Inc. or Authority approved equal.

2.12 LIGHTNING ARRESTERS AND EQUALIZERS

Lightning arresters and equalizers shall be mounted on three post porcelain or approved type base and shall be in accordance with AREMA Signal Manual Part 14.1.9.

2.13 TERMINALS FOR WIRES AND CABLES

A. All solderless terminals shall be in accordance with AREMA Signal Manual Part 14.1.1, or as specified herein.

B. Terminals shall be of the solderless crimp-on type. Samples of all solderless terminals shall be submitted for approval.

C. All stranded copper wire shall be fitted with an approved type of terminal at all points where the wires are to be terminated on terminal binding posts.

D. The terminating means shall be of five types:

1. A lug for terminating heavy wires or signal power wires;

2. A solderless insulated terminal as manufactured by AMP, Inc. under the trade name of "Ring Tongue Plasti-Bond", similar to Catalog No. 35628, Hubbel, Thomas & Betts or approved equal, for terminating No. 16 and No. 14 AWG stranded wires; A solderless insulated terminal similar to AMP Catalog No. 35627, Hubbel, Thomas & Betts or approved equal, for terminating insulated wires Nos. 12-10;

3. A solderless insulated terminal similar to AMP Catalog No. 324108, Hubbel, Thomas & Betts, or approved equal for terminating other stranded vital circuit insulated wires No. 20-16 AWG having a maximum diameter of 0.200 inches;

4. A solderless insulated terminal, AMP Catalog No. 320554, Hubbel, Thomas & Betts or approved equal, shall be furnished for No. 8 studs and AMP Catalog No. 32057l Hubbel, Thomas & Betts or approved equal, shall be furnished for one-quarter inch studs for non-vital circuit insulated stranded wires No. 22 - 16 AWG having a maximum diameter of 0.125 inches.

E. Where flag type terminals are required they shall be similar to AMP Catalog No. 322313, or approved equal, for terminating No. 16 and No. 14 AWG stranded wires. Other pre-insulated terminals shall be similar to those shown in AMP Product Bulletin No. 109-1.

F. The terminals shall be for attaching to the ends of the conductor in such a manner that the flexibility of the conductor will not be destroyed and the possibility of breakage at the terminal will be reduced to a minimum.

G. Terminals shall be for attaching to the wire with a tool made by the manufacturer of the terminal and recommended by him for the terminals being furnished.

H. The tool shall be equipped with a ratchet device to insure proper indentation of the terminal and which will not release until proper indentation is complete. Three such tools shall be furnished by the Contractor.

2.14 TAGGING FOR CABLES, WIRES AND EQUIPMENT

A. Except as otherwise specified in this Section, both ends of each cable and each cable wire and all single wires that terminate in the wayside cases, junction boxes, switch mechanisms, central instrument housings on entrance racks, and any equipment of the signal system outside of such locations shall be permanently identified with a tag. Tags shall not obscure connecting links used between terminal binding posts. Tags shall be installed so that they may be read with a minimum of disturbance of the tags and wiring. Each conductor of the cable shall be rung out and identified before applying the tag.

B. Tags for wire and cable identification and for identification of transformers, resistors, reactors and other components shall meet the following requirements and shall be subject to the approval of the Engineer:

1. Sleeve Type Tags:

   Tags for identification of individual cable conductors and field-installed wires within the wayside cases and central instrument housings, switch mechanisms, switch layout junction boxes, base of signal junction boxes and similar applications shall be the sleeve type as manufactured by Raychem Corporation, RPS-1K-8-4/2.0-9, Brady, Panduit or an approved equal. The application of the conductor nomenclature shall be in accordance with the manufacturer's instructions and shall result in a permanently bonded and legible identification, or approved equal.

2. Tags for cables shall be the PANDUIT flag type, or approved equal.

3. Flat Plastic Tags:

   a. Tags for identification of vital relay plug boards, individual transformers, resistors, reactors, terminals, and other miscellaneous components within the wayside cases, central instrument housings and outside terminal cases and snowmelter cases shall be the flat plastic laminated type.

   b. These tags shall be one and one-half inches long by three-quarter inch wide with one, five--six-tenth inch hole located in the center of the width. The distance from the edge of

tag to the hole shall be approximately nine thirty-seconds of an inch. The untreated tag shall be milk white "vinylite", or approved equal.

c. The identifying nomenclature space shall allow for three rows of lettering, and the tag material shall be capable of receiving typed-on characters by conventional means. The height of the lettering shall be not less than one-eighth inch.

d. After lettering, both the face and back side of the tag shall be covered with a clear plastic coating, "vinylite", or approved equal, of at least one hundredth of an inch thick.

e. The nomenclature applied to tags to go on entrance racks and boards shall show the terminal post identification on the top line. The functional nomenclature shall appear on the bottom line, or, if required, on the middle and bottom lines. The terminal posts shall be identified by geometry coordinates, such as rack, row and post number.

C. Wrap Around Tags. Tags for identification of the individual wires of plug-in relays, within the signal instrument house and the wayside cases shall be the wrap around, self-adhesive type.

D. Flag Marker Tags. Tags for identification of individual wires of shelf-mounted relays and wires and conductors in junction boxes shall be flag marker tags of the miniature locking type.

2.15 PRESSURE SENSITIVE LABELS

A. The rows and columns on entrance racks shall be identified by pressure-sensitive labels bearing the geometric coordinates.

B. Wires on plug-in vital relays shall be identified by the contact to which they are applied. These tags shall be wrap-around self-adhesive type.

2.16 HARDWARE

A. All mounting hardware exposed to the elements and used for signal equipment, cases, conduit, hangers, brackets, clamps, etc., shall be hot-dip galvanized, except as otherwise approved by the Engineer.

1. Galvanizing:

a. The hot dip process of galvanizing shall be used. All parts shall be pickled so that all scale and adhering impurities will be removed. The zinc coating shall be of commercially pure zinc, and shall be continuous and thorough. It shall not scale or blister or be removable by any of the processes of handling or installation. The finished surface shall be free from fine line cracks, holes, or other indications of faulty galvanizing. It shall be smooth and free from adhering flux and other impurities. The edges and ends of parts shall be free from lumps and globules. Parts shall be coated with at least two ounces of zinc per square foot of galvanized surface, after all bending, cutting, drilling, and final fabrication.

b. In order to avoid destruction of resilience encountered in the hot dip process of galvanizing, all lock-washers shall be cadmium plated.

2. Cadmium Plating:

a. All nuts, bolts, and washers used for the mounting of equipment within finished enclosures shall be cadmium plated or stainless steel. As an alternate, the Contractor may submit another type of plating or non-corroding metal for the Engineer's approval.

b. Cadmium plating shall be an impervious, dense, hard, fine grained, continuous, closely adhering coating of commercially pure cadmium, free from capillaries and shall completely cover the surface of the part in a smooth, bright layer. Plating on raised or prominent portions shall show no evidence of blackness or loose crystalline structure. It shall have a minimum thickness of six ten thousandths of an inch and shall withstand the salt spray test for at least l000 hours or an equivalent test approved by the Engineer.

2.17 FLEXIBLE CONDUIT AND HOSE

A. Hose for track circuit leads, switch and lock movements, cc boxes and electric locks shall be braided cordura rayon, vari-purpose hose, internal tube neoprene cover or authority approved equal. The hose shall be clamped at both ends with stainless steel clamps. Clamps are not required for track risers.

B. Flexible conduit: Where the engineer permits the use of flexible conduit it shall be type UA or approved equal.

2.18 STAINLESS STEEL CLAMPS

Clamps for clamping hose at each end shall be stainless steel.

2.19 NOT USED

2.20 NOT USED

2.21 SEALING COMPOUND

Sealing compound for use in sealing cable entrances shall be in accordance with AREMA Signal Manual Part 15.2.15.

2.22 PAINT AND FINISH

All paint and painting procedures shall be in accordance with applicable requirements of AREMA 1.5.10., where the AREMA requirements do not conflict with any requirement of these Specifications. The Project Engineer will resolve any conflict.

2.23 CABLE ENTRANCE PIPES

A. Cable entrance pipes for ground-mounted wayside signal cases shall be four (4) inch galvanized steel, three feet-six inches (3'-6") long, threaded on one end, reamed and chamfered and shall be furnished complete with one (1) locknut and one (1) bushing for each such pipe. One spare entrance pipe assembly shall be furnished for each ground mounted wayside case.

B. Cable entrance pipes for ground-mount signal instrument houses shall be four (4) inch galvanized steel, three feet-six inches (3'-6") long, threaded on one end, reamed and chamfered and shall be furnished complete with one (1) locknut and one (1) bushing for each such pipe. One spare pipe shall be furnished and installed within each Signal Instrument House.

2.24 GROUND RODS AND WIRE

A. Ground rods shall be copper-clad steel, of the non-rusting type as manufactured by Copperweld Corporation, or approved equal. The rod shall be at least eight feet in length and at least five-eighths inch diameter for signal equipment. Ten feet in length and at least three-quarters inch diameter minimum for service equipment.

B. Internal ground wire, from the equipment to the ground bus shall be insulated No. 6 or 10 AWG stranded copper wire, as specified within the detail sections of the Specification. Insulated ground wire shall be colored green.

C. A grounding bus of nickel plated hard drawn pure copper shall be provided in each signal instrument house and wayside instrument case. The minimum dimensions of this bus shall be eight inches by eight inches by one-half inch thick. A minimum of twelve, three-eighths inch holes shall be drilled and tapped in the bus and twelve, three-eighths inch by one-half inch long hex head nickel plated bronze studs with one washer each shall be installed.

PART 3 - EXECUTION

3.1 INSTALLATION

All material and apparatus specified herein shall be installed in accordance with the detail of respective technical sections of these Specifications and in accordance with the Contract Drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for miscellaneous components and products but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the miscellaneous components and products work will be considered incidental to the Lump Sum price.

END OF SECTION

SECTION 16898

SIGNAL SYSTEM TESTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The majority of signal system operational testing shall be performed by the Operating Railroad. This Section specifies the tests and inspections that the Contractor shall perform to demonstrate that installation of systems, subsystems, assemblies, subassemblies, and components supplied and/or installed under this Contract are in compliance with the Specifications. In addition to the signal systems these tests also include, but are not limited to: testing of the electric services and communications. Contractor shall be responsible for field testing only; factory tests and their results will be handled by others.

B. The work shall include the costs of the Contractor's personnel and any special equipment and assistance required to conduct all tests and complete the required documentation.

C. In the event that the system does not meet the Specification requirements, necessary corrections shall be made and any and all tests or re-tests to prove compliance shall be included in the work, without any additional cost to this Contract, including additional MBTA costs.

D. Test work specified elsewhere in these Specifications shall be construed as related to and inclusive with the testing described herein.

E. The Contractor shall notify the Engineer two weeks prior to field tests that require the presence of the Authority, their designated representatives, and/or any other regulatory agency.

F. Tests and inspections shall be made both during the field installation phases and final acceptance testing with the Operating Railroad. These tests shall consist of, but not be limited to, circuit breakdown tests, wiring verification tests, continuity tests, resistance tests, voltage and current tests, time tests, operating tests, simulation tests, and other electrical and mechanical tests and inspections.

1. The Engineer reserves the right to witness any or all tests and inspections in the Contractor's plants or other manufacturing facilities. The Engineer shall be advised a minimum of sixty days in advance of each factory test.

2. All approved system and subsystem tests to demonstrate that the assembly/installation meets these Specifications and design requirements shall be completed prior to any operational testing of systems or subsystems.

G. The work shall include necessary disconnecting and re-connecting required for testing purposes and temporary phasing of work.

H. The Contractor shall ensure that qualified technical assistance is provided during testing, cut-overs and other designated milestones identified in the schedule during the field installation phase of the Contract.

I. Testing plans and procedures shall account for and incorporate any interim signaling arrangements as required by phased or partial installation schemes.

1.2 STANDARDS, REGULATIONS and PROCEDURES

A. Standards – AREMA C&S Manual, Part 2.4.1 "Instructions for Inspection and Test of Signal Installations before Placing in Service".

B. Regulations - Federal Railroad Administration, Rules, Standards and Instructions for Railroad Signal Systems, Part 236 and Part 234 inclusive.

C. The Operating Railroad C&S-1 test procedures.

D. MUTCD Part 8, where applicable.

E. MBTA- CRDS, where applicable.

1.3 QUALITY ASSURANCE

A. All test procedures and inspection procedures shall be subject to the approval of the Engineer and shall comply with all FRA rules and regulations and AREMA, MUTCD and Operating Railroad recommendations.

B. Provide a listing (matrix) of all testing required for each component of the procedures as approved for all testing required for acceptance. The Contractor shall design the matrix in a manner that shall allow an immediate reference to the status of the testing and the remaining time to complete. One matrix shall be provided for installation testing and another for final field testing with the Operating Railroad. Tests to be included in the matrices shall include, but not be limited to, the following:

1. Pre-installation Inspection,
2. Ground Resistance Tests,
3. Crossing signal tests,
4. Signal Adjustment & Check-out Test,

C. Satisfactory performance of the installation testing will not waive the requirement for performance of the same or similar tests as part of the final field acceptance testing procedures without specific written authorization from the Engineer.

D. Test equipment of the proper type, capacity, range and accuracy shall be supplied by the Contractor to perform the required tests and inspections. This equipment shall be in good working order and properly calibrated within 180 days of the time the tests or inspections are conducted.

The calibration of each instrument shall be certified by a recognized testing facility. Instruments, not calibrated within the last 180 days will be considered as non-certified. Tests conducted with non-certified instruments will be rejected.

E. Each component and unit of the wayside signal system shall have an inspection performed at its point of manufacture and evidence of this inspection and acceptability shall be indicated on the item where practicable.

F. The work shall include all tests required to ensure the proper and safe operation of all systems and subsystems and to prove the adequacy and acceptability of the total assembly/installation specified herein. The tests to be performed shall cause each system and subsystem to be sequenced through its required operations, including the imposition of simulated conditions to prove that the assembly/installation complies with all specified fail-safe requirements.

G. The Engineer will have the right to witness any or all field tests conducted. The Engineer shall be notified in writing prior to each field test. No part of the signal system shall be placed in service without an authorized representative of the MBTA witnessing and certifying successful completion of the in-service test procedures by signoff on the completed test forms

1.4 SUBMITTALS

In accordance with the requirements of Section 01300 – Submittals, the Contractor shall submit the following:

A. Within 60 days after receipt of Notice to Proceed, submit:

1. An outline and initial (draft) procedures for the tests to be performed on each type of component or unit and a matrix showing each test and the equipment to be checked, together with samples of test record forms and matrices as hereinafter specified.
2. The numbers of each type of component or unit to be tested to demonstrate the adequacy of design and quality control.
3. A line diagram showing the grouping and sequencing of system and subsystem tests identifying individual field tests.This line diagram shall also show time relationships for all activities and indicates relative manpower (staffing) requirements.

B. At least 30 days prior to the scheduled testing of the first location, and in accordance with the approved schedule, submit detailed test procedures for approval of the Engineer. The detailed test procedures submittal shall also include all pertinent information regarding the simulating devices and the methods of simulation to be employed in effecting a complete functional/operational series of tests.

1. Provide a complete set of “test data sheets” as part of the detailed test procedures submitted. These data sheets shall contain all information required to successfully perform the tests, including identifying acceptable ranges of test results and pass/fail criteria.

C. At least. 60 days prior to the scheduled performance of each test a detailed test schedule(s), as described herein, shall be submitted for approval of the Engineer.

1. The detailed test schedule(s) for significant cut-over and testing activities shall outline the Contractor's activities by task, expected duration and associated manpower requirements.

2. Within the projected schedule, a description of expected transportation impact should be addressed. Requests for track & power outages, flagging, etc. should be identified in sufficient detail.

D. The results of each test as herein specified, both factory and field shall be recorded and the completed data package including all forms and marked plans shall be furnished to the Engineer within 5 days of completion of the test. Certified test results shall also be furnished for tests performed by any subcontractors when such tests are required within this Specification.

E. All test reports shall be checked and approved by the Contractor prior to submittal to the Engineer.

F. Test reports shall document the calibration date of each instrument used during the test.

G. Upon completion of all tests specified herein, the Contractor shall submit a letter signed by an authorized representative, certifying that all tests have been performed.

PART 2 - PRODUCTS

2.1 SITE TEST EQUIPMENT AND MATERIALS

A. The Contractor shall have all test instruments and equipment necessary to conduct the required tests, including two spare sets of all equipment, available and ready for use not less than one week in advance of test need. "Ready for use" shall mean properly matched for test parameters, properly calibrated, properly programmed, sufficiently supplied with leads, probes, adapters, stands etc. necessary to conduct the particular test in a completely professional manner.

B. All temporary or interim test related materials, special tools, connections, jumpers, etc. shall be furnished and available not less than one week in advance of the test need. This shall also include all materials required to accommodate temporary or interim signaling arrangements.

PART 3 - EXECUTION

3.1 FIELD TEST PROCEDURES

A. The quality of the installation shall be demonstrated by field tests for continuity, insulation resistance, resistance to ground, circuit breakdown, visual inspection, megger tests and any other tests required by these Specifications. These tests shall be performed prior to any operational testing of systems or subsystems.

B. The Contractor's test procedures package shall include pre-approved, pre-printed data sheets and/or inspection sheets for each test. When completed by the field test personnel and checked for

accuracy and completeness, the sheet shall be submitted as the test report. Contractors test results sheets shall conform to all state and federal requirements for preprinted information contained therein.

C. When tests require specific meter or test instrument readings, the pre-printed data sheet shall show the allowable range of values, for each part of the test. The test report shall also contain a check-off system for each action and a blank space adjacent to the expected value in which to record the test readings.

D. The test report shall also contain a final description sheet on which the Contractor shall record discrepancies found and action taken. This documentation shall be furnished to the Engineer.

E. All test reports shall be dated and signed by the responsible employee of the Contractor or subcontractor on the day the test is performed. Space shall also be provided for the signature of the witnessing inspector, engineer, or otherwise MBTA designated representative.

F. The report shall show the specific test instruments used on each test, with the instruments identified by name, type, serial number, and calibration due date.

G. Should an error be discovered during field testing, due to field wiring and connections that do not agree with the approved circuit plans, the Contractor may correct such errors without prior approval of the Engineer. The Contractor shall not, however, make any changes that affect safety of operation of the approved circuit(s), as designed, without prior written approval of the Engineer.

H. The Engineer will make all final determinations as to whether or not the entire test, shall be re-run when any specific field test does not meet the requirements specified for the test.

I. Any changes made after completion of test procedure shall be re-tested in accordance with the applicable test procedure.

3.2 FIELD TESTS AND INSPECTION

A. General Field Tests - General field tests shall include, but not be limited to, those required by the approved matrix and the following:

1. Ground verification test,

2. Energy distribution system and power tests,

3. Line circuit verification between wayside instrument houses,

4. All applicable tests prescribed by FRA, AREMA C&S Manual Part 2.4.1, and Operating Railroads C&S-1,where these inspections and tests do not conflict with the requirements of these Specifications.

B. Specific Field Tests

1. Preliminary Verification Tests

The Contractor shall use the Contract Drawings and existing MBTA documentation or other approved drawings to confirm all existing cables and terminations. Within a reasonable period of time from the Notice to Proceed the Contractor shall submit to the Engineer the results of these inspections. This documented examination shall utilize pre-approved forms and be conducted by the Contractor's signal engineer. The process shall include the inspection of existing SIH's, wayside signals, junction boxes and cases required to be interfaced with or requiring modified wiring and confirm that:

a. All individual wiring is terminated as indicated by the approved documentation package;

b. The terminated wires contain the number of conductors on each terminal as indicated by the approved documentation package;

c. That all cables include the number of wires and are the wire gauge indicated by the approved documentation package;

d. That the existing nomenclature tags are in conformance with the approved documentation package;

e. That the number of cables entering and leaving is in conformance with the approved documentation package.

2. Cable Routing Inspections

Within a reasonable amount of time, but no longer than 60 days from the receipt of Notice to Proceed the Contractor shall submit documentation showing the results of his inspection of cable routings and raceway areas intended for use under this Contract. The Contractor shall confirm the adequacy of proposed routing & methods and report any perceived problems or areas of concern.

3. Resistance of Ground Connection Test

All grounding connections shall be tested to determine that the ground resistance is not greater than 15 ohms using the approved Ground Resistance test method. All ground connections shall be tested.

4. Insulation Resistance Tests

The test procedure for testing of insulation resistance shall include tests to verify the following:

a. All wire and cable installed along the right-of-way and the wire and cable entering or leaving wayside instrument cases and houses shall be tested after installation, including termination, to ensure that insulation of wires and cable and connected equipment meet the specified resistance value. A direct reading instrument, having a 0-megohm to 200-megohm scale range and a self-contained DC power supply rated 500 volts (minimum) to 1000 volts (maximum), shall be used to

measure the insulation resistance. Resistance between conductors and ground shall not be less than that specified in the Federal Railroad Administration Rules, Standards, and Instructions for Railroad Signal Systems, Part 236.108.

b. If any of the wire connections affected by installation, maintenance or repair work involving vital conductors that leave the house, case, junction box or device, or if such conductors are replaced or installed or spliced, then the insulation resistance of those conductors must be tested to each other and to earth ground prior to any other safety certification tests. Simply opening and closing slider straps are not considered to be work affecting the conductors. Insulation resistance of new conductors must be no less than 1 Meg Ohm for 600V-class cable and no less than l00Meg Ohm, for 1000V-class cable. Conductors with insulation resistance measured less than 500k Ohm must be repaired without undue delay. Conductors with insulation resistance measured less than 200k Ohm must be taken out of service for repair immediately. Power sources, made grounds and connections to the rails shall be disconnected from the circuits during testing.

c. The point used as ground shall be the most convenient ground available.

d. Insulation resistance test values shall be recorded on approved Insulation Resistance Record Forms and turned over to the Engineer upon his acceptance of this test requirement.

5. Energy Distribution

These tests shall be conducted on all energy busses:

a. Energy-Off Tests

With all power to wayside instrument house or case off, the following checks and tests shall be performed. These shall include but not be limited to:

1) All fuses shall be removed.

2) Verify that circuit breaker size compares to that of approved circuit plans.

3) All energy distribution shall be checked using resistance test instrument acceptable to the Engineer, to verify agreement with the approved plans.

4) Compare wire gauges with those called for on the approved circuit drawings. All discrepancies in wire sizes shall be replaced with the proper size wire.

5) During energy distribution breakdown, a wire count on each terminal, relay contact, etc. shall be taken to ensure that only the number of wires called for on the approved circuit plans is present at each terminal, relay contact, etc. Any discrepancies found shall be corrected and additional wires, if found, shall be removed.

6) Tags shall be verified for proper nomenclature and terminal location.

7) Each energy bus shall be tested to all other energy buses to ensure that no crosses exist.

b. Energy-On Tests

Upon completion of the energy-off tests, the following checks and tests which shall be performed. These tests shall include but not be limited to:

1) Insert fuses for power supply feeds and verify proper size according to the approved circuit drawings.

2) Turn on energy feeds and test operation of power transfer for proper operation.

3) Each AC voltage input shall be measured and recorded.

4) Each power supply or charger output voltage shall be measured and recorded.

5) Verify that the proper voltage is present at all distribution points.

6) Check battery fluid level and specific gravity of all cells as applicable per manufacturer's recommended installation/maintenance procedures.

6. Circuit Continuity Tests

All wire and cable installed by the Contractor shall be tested to verify the continuity of each conductor and that each conductor is connected to the proper terminal as shown on the approved drawings. Where parallel circuits exist, each parallel path shall be tested independently to verify the continuity of each path.

7. Vital Circuit Breakdown

The vital circuit breakdown test consists of three major steps; wire counts, continuity and finally, contact verification. A copy of applicable drawings shall be used as data sheets for this test. Green and brown colored pencils are required for documenting this test on the data sheet. Green circled numbers indicate wire counts at connection points. Green tracing on circuit conductors indicate continuity verifications. Brown check marks indicate contact verifications.

a. Wire Counts: The first step is to make a physical count of number of wires connected at each point in the circuit, for all circuit points worked on by personnel for the maintenance or modification being tested. The number of wires connected at each point must agree with the drawing. For each verified connection point, write and circle the number of wires found connected to that point next to it on the data sheet. Resolve any discrepancies before proceeding to the next step.

b. Continuity: The second step is to verify continuity of the circuit conductors as drawn, one conductor at a time. If, according to the drawing, a conductor is electrically connected to more than two points and it is impractical to separate those multiple terminations, verify the continuity to each of those points. Perform this test on each conductor that is connected to any of the circuit points worked on by personnel for the maintenance or modification being tested. To perform this portion of the test, all relay contacts, slider straps and termination points to which the conductor(s) is connected must be verified open. (Removing vital relays from their plug boards may simplify the opening of relay contacts; however, this method may become complicated when processor I/O circuits are involved.) Also, confirm that no energy is present on the conductor. Verify the continuity of the conductor from one end to the other. For each conductor so verified, trace the conductor on the data sheet for its entire length using green pencil. Resolve any discrepancies before proceeding to the next step.

c. Contact Verification: The third step of the vital circuit breakdown test consists of applying the vital circuit's normal energy under the conditions required to energize the vital component. Some of the conditions may have to be simulated. If conditions are simulated, as much as possible they should be simulated outside the circuit being tested by forcing relays or other devices to the desired state. Specific details of each method used to simulate conditions must be approved and documented in the logbook, immediately, during the tests. One at a time; each relay contact, circuit controller contact, slider strap and test link in the circuit, must be opened to interrupt the circuit current and verified to de-energize the vital relay or device.

In cases where a contact under test is intended to provide a circuit shunt, such as that of a circuit controller shunt contact, an ohmmeter must be used at the relay coil or other vital device to verify the circuit makes and breaks the shunt as intended. In cases where the circuit load is a motor or other high current device, a voltmeter may be used to simulate the motor. When a meter is used in place of the normal load, it should be placed as close as practical to the load device, and never in the portion of the circuit that was modified or repaired.

This contact verification test must be performed for all circuit points worked on by personnel for the maintenance or modification being tested and one circuit point further into each circuit branch. As each contact is verified, write a brown pencil checkmark next to the contact on the drawing. Resolve any discrepancies before proceeding to the next step. Immediately following the test, review the logbook and verify that all simulations used during the test have been restored to normal configurations. After the vital circuit breakdown test verifies that the circuit is wired as it is drawn, perform all applicable functional tests to verify the circuit functions in a safe manner.

8. Non-Vital Circuit Breakdown

All circuits not checked during factory test or modified after factory test shall be checked for accuracy against the approved circuit drawings. Tests may be done with energy on or off and shall verify, but not be limited to, the following:

a. Point to point wiring.

b. A wire count of all field installed wires shall be made for each terminal, relay contact, etc. to ensure that only the number of wires called for on the approved circuit plans is present at each terminal, relay contact, etc. Any discrepancies found shall be corrected.

c. Verify tags and nomenclature where applicable.

d. Verify that all components, relays, resistors, etc. are the same as called for on the approved circuit drawings and located in proper positions.

9. Track Circuits

Tests shall be made to assure that all track circuits are properly installed, phasing is checked, and the complete circuit is adjusted in accordance with the approved detail test procedure and MBTA/MBCR standard test forms. The Contractor shall assist in the testing for the proper rotation of the phasing for track circuits. Each track circuit shall be tested in accordance with the manufacturer's approved test procedure and shall include tests to verify the following:

a. Each track circuit shall be tested for defective insulated joint protection.

b. Each track circuit shall be tested for shunting sensitivity. A 0.06 ohm shunt strap shall be placed across the rails at the track feed, track receiver and all fouling points. The track circuit shall meet the requirement of FRA Rule 236.56, except with the track relay to be in the de-energized position with the 0.06 ohm shunt. This test shall be performed after the final track circuit adjustment has been made. Value of current required to pick up the track relay shall be recorded.

c. Each track relay shall be tested to assure that the proper phase relationship exists between the track energy being received and the local source used for comparison using the methods approved by the Engineer.

10. Signal layouts

Tests shall be performed on all signal layouts. These tests shall include, but not be limited to the following:

a. Check continuity of field wires and verify all nomenclature.

b. Apply energy to signal lighting circuits and adjust all LED unit voltages to 10 percent less than the nominal rating.

c. A functional test of signal lighting circuits must be performed after appropriate megger and circuit breakdown test(s) are complete, and whenever any signal

lighting circuit conductors in the train control room, yard case, junction box or signal head are disconnected/connected during maintenance or modification.

11. Power Tests

The following power tests shall be made and recorded:

a. The voltage of the main power feeders shall be measured and recorded.

b. Perform functional tests of the automatic transfer switching arrangements.

c. Check of all fuses for correct size and type.

d. Check all power supplies, battery chargers, and batteries for correct setting and quantities and include arrangements for testing various load sharing scenarios.

e. Bus-to-bus checks shall be made to determine that no shorts, crosses or grounds exist.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for signal system tests but all costs in connection therewith shall be included in the Lump Sum price for Item No. 490.01 - Railroad Grade Crossing Reconstruction except as otherwise noted. All preparation and incidental work necessary to accomplish the tests will be considered incidental to the Lump Sum price.

END OF SECTION